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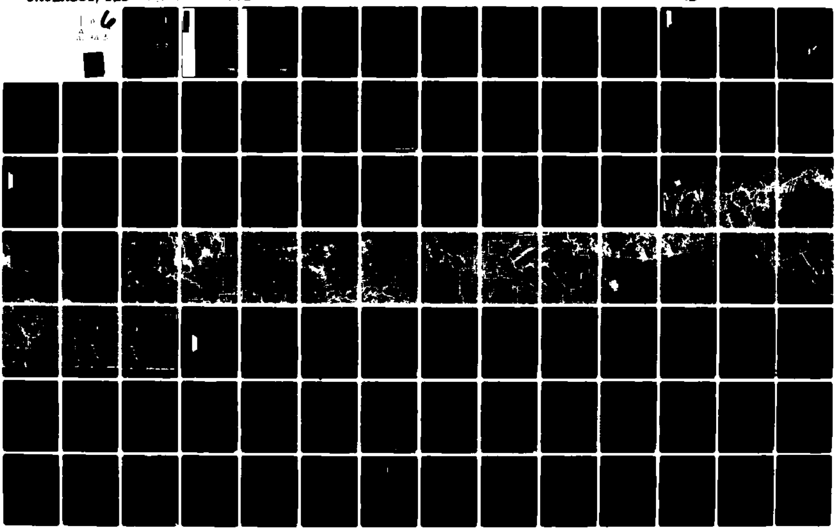

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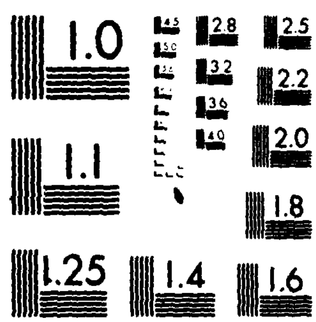

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GEOTECHNICAL EVALUATION

VOLUME I
ARIZONA
VERIFICATION STUDIES, FY 79
and
GEOTECHNIAL DATA,
LA POSA CDP, ARIZONA

PREPARED FOR

SPACE AND MISSILE SYSTEMS ORGANIZATION (SAMSO)

NORTON AIR FORCE BASE, CALIFORNIA

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Consulting Engineers and Geologists

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FN-TR-28-I

MX SITING INVESTIGATION
GEOTECHNICAL EVALUATION
VOLUME I, ARIZONA
VERIFICATION STUDIES, FY 79
AND
GEOTECHNICAL DATA
LA POSA CDP, ARIZONA

Prepared for:

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15 November 1979

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents results of a geotechnical verification investigation which has been conducted during the 79 fiscal year within southwestern Arizona. ~~A verification invest also conducted in portions of Nevada + Utah~~

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FOREWORD

This report was prepared for the Department of the Air Force, Space and Missile Systems Organization (SAMSO), in compliance with conditions of Contract No. F04704-78-C-0027, CDRL Item 005A2. It presents geological, geophysical, and geotechnical data and evaluations on the suitability of an area in southwestern Arizona. This study area is an alternate siting area for the MX Land Mobile Advanced ICBM System.

This is the first report of Verification studies for the Arizona study area. The objective of the Verification studies is to verify the suitability of sufficient area for deployment of the MX system. The Verification studies are the final phase of a site-selection process which was begun in 1977. Previous phases have been termed Screening, Characterization, and Ranking. In preparing this report, it has been assumed that the reader is familiar with these previous studies.

In this report, discussions are limited to the hybrid trench and vertical shelter basing modes. In most cases, the discussions and data for hybrid trench also apply to the horizontal shelter since the depth of excavation is about the same. In particular, suitable area for the hybrid trench will also be suitable for the horizontal shelter.

This report consists of two volumes:

* Volume I - Sections 1.0 and 2.0 contain Introduction and Results and Conclusions. Sections 3.0 and 4.0 contain summary geotechnical discussions for La Posa and Butler CDPs, respectively. Volume I also includes Geotechnical Data for La Posa CDP.

  Volume II - Geotechnical data for Butler CDP.

* This volume is presented herein.

TABLE OF CONTENTS

Table of Contents (Cont.)

LIST OF TABLES

TABLE OF CONTENTS (Cont.)

LIST OF FIGURES

LIST OF DRAWINGS

1.0 INTRODUCTION

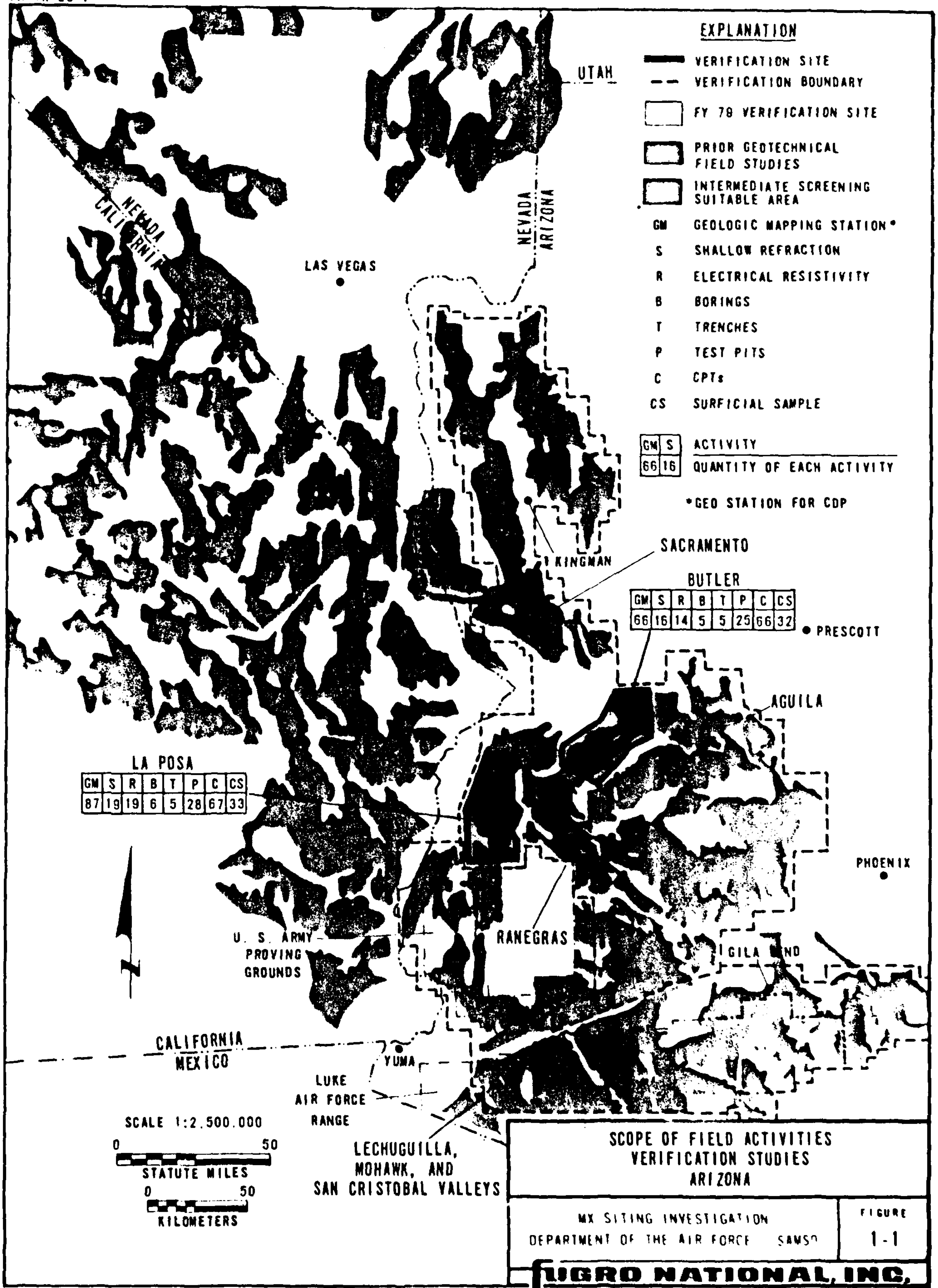
1.1 PURPOSE AND BACKGROUND

This report presents the results of a geotechnical Verification Investigation which has been conducted during the 1979 fiscal year within southwestern Arizona (Figure 1-1). A Verification Investigation was also conducted in portions of Nevada and Utah; the results were presented in a separate report (FN-TR-27).

Verification is the final phase of a site selection process which was begun in 1977 to identify several regions, each containing between 6000 and 7300 mi^2 (15,500 and 18,900 km^2), which will be "suitable" (see Appendix Section A2.0 for criteria) for deploying the MX Advanced Intercontinental Ballistic Missile System.

Preceding phases of the site selection process were:

1. SCREENING: Nationwide literature and map studies to identify potentially suitable areas based on a set of geotechnical, cultural, and environmental criteria. The study was conducted in three phases: Coarse, Intermediate, and Fine. At the completion of the Fine Screening phase, approximately 74,000 mi^2 (192,000 km^2) of area had been identified as potentially suitable in seven states in the southwestern United States.
2. CHARACTERIZATION: Field studies in representative areas, in combination with more detailed literature and map studies, to better define the geotechnical conditions and


EXPLANATION
VERIFICATION SITE
VERIFICATION BOUNDARY
FY 79 VERIFICATION SITE
PRIOR GEOTECHNICAL FIELD STUDIES
INTERMEDIATE SCREENING SUITABLE AREA
GM GEOLOGIC MAPPING STATION*
S SHALLOW REFRACTION
R ELECTRICAL RESISTIVITY
B BORINGS
T TRENCHES
P TEST PITS
C CPTs
CS SURFICIAL SAMPLE
GM S ACTIVITY
66 16 QUANTITY OF EACH ACTIVITY
*GEO STATION FOR CDP
UTAH
NEVADA
CALIFORNIA
NEVADA
ARIZONA
LAS VEGAS
KINGMAN
SACRAMENTO
BUTLER
GM S R B T P C CS
66 16 14 5 5 25 66 32
PRESCOTT
AGUILA
LA POSA
GM S R B T P C CS
87 19 19 6 5 28 67 33
PHOENIX
RANEGRAS
U. S. ARMY PROVING GROUNDS
GILA BEND
CALIFORNIA
MEXICO
YUMA
LUKE AIR FORCE RANGE
LECHUGUILLA, MOHAWK, AND SAN CRISTOBAL VALLEYS
SCALE 1:2,500,000
0 50
STATUTE MILES
0 50
KILOMETERS
SCOPE OF FIELD ACTIVITIES
VERIFICATION STUDIES
ARIZONA
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO
FIGURE 1-1
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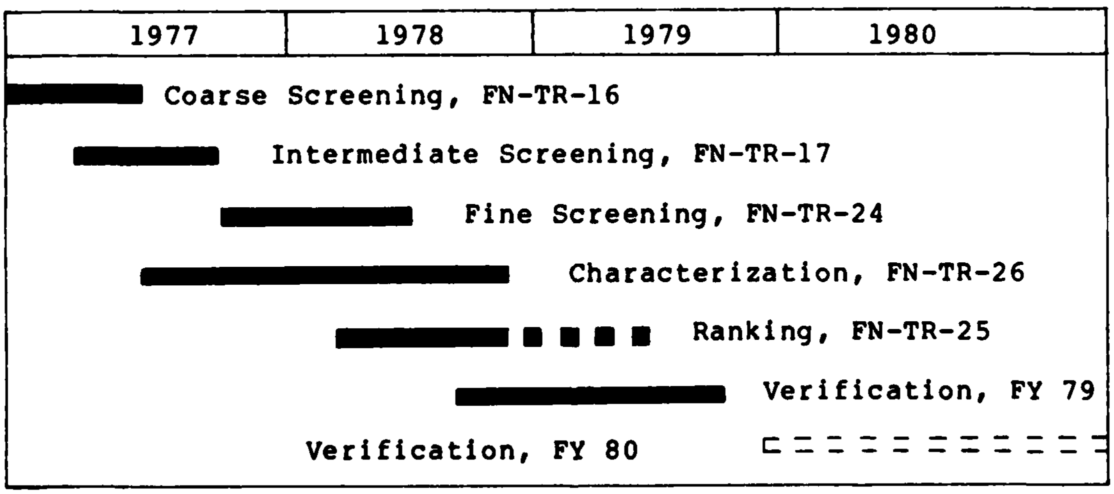
refine the boundaries of suitable areas that had been identified during the screening studies.

3. GEOTECHNICAL RANKING: A geotechnical comparison of seven candidate siting regions, based on the relative cost of geotechnically related construction items. The rankings were performed for the hybrid trench, vertical shelter, and horizontal shelter basing modes.

The schedule of these studies is shown in the following diagram which also identifies the Fugro National technical report for each.



The intent of the Verification phase is to refine and improve confidence levels in the boundaries of suitable areas that were determined from the previous site selection programs. In contrast to these previous programs that were based primarily on published information, the Verification studies are based on field investigations. These studies have concentrated on refining the boundaries of the suitable area and obtaining geotechnical data for preliminary engineering design use prior

to site-specific studies. The design and scope of the Verification studies are based on the results of the Geotechnical Ranking which pointed out the geotechnical factors that have the greatest influence on construction costs.

Additional geotechnical programs were conducted in the Arizona area prior to and simultaneous with the geotechnical screening program. The most notable of these programs, the Geotechnical Methodology Studies, was conducted in Mohawk-Tule Valley (Fugro TR-18), Lechuguilla Desert (Fugro TR-19), and San Cristobal Valley (Fugro TR-WR), which are part of the Luke Bombing and Gunnery Range located east of Yuma, Arizona (see Figure 1-1). The principal objective of these studies was the evaluation of geotechnical techniques to be used in site-specific MX studies.

Additionally, data were collected in three sites during the Arizona Characterization Program which led to an evaluation of their suitability for MX. These sites were: Ranegras and Aguila (Fugro TR-26d) and Sacramento (Fugro TR-26e) (Figure 1-1).

1.2 OBJECTIVES FY 79

The FY 79 geotechnical Verification studies in the Arizona study area have two major objectives:

1. Verify and refine the boundaries of the suitable areas in two CDPs for vertical shelter, horizontal shelter, and hybrid trench basing modes.
2. Provide preliminary physical and engineering characteristics of the soils.

1.3 STUDY APPROACH AND SCOPE

1.3.1 Study Approach

Verification studies conducted in the Arizona study area differed from those undertaken in the Nevada-Utah study area in that only two Verification sites were studied and no reconnaissance was performed in the remaining areas.

Studies in these two sites, when combined with studies from previous programs in the Arizona siting area, will account for nearly 40 percent of the available suitable area. More Verification studies and/or reconnaissance could be conducted at a later date to make the program in the Arizona study area similar to that conducted in Nevada-Utah.

The Arizona study area was divided into 21 Candidate Deployment Parcels (CDPs). CDPs are discrete geographic units devised for organization and management of geotechnical, environmental, and cultural data collected during FY 79. CDPs in themselves do not imply final boundaries or areas for MX deployment. The suitable area within each CDP, prior to the Verification studies, typically varied between 200 and 500 mi^2 (520 and 1300 km^2). La Posa and Butler CDPs were selected for study on the basis of providing data on a representative geographic and geotechnical basis for the Arizona study area.

The Verification studies consisted of a combination of geologic, geophysical, and soils engineering investigations designed to determine those parameters required for defining suitable area and to obtain basic information about the geotechnical characteristics of the basin-fill materials. The field program is shown

schematically in Table 1-1. The parameters which were evaluated are shown as column headings and the applicable investigative techniques are listed below. The techniques are described in detail in the Appendix.

Prior to starting field studies, a program plan was developed, logistics were planned, and photogeologic interpretations were initiated. Access was arranged through the Phoenix district office of the Bureau of Land Management (BLM). At the request of the BLM, all field activities were performed along existing roads or trails to minimize site disturbance. Archaeologic and environmental surveys were performed at each proposed activity location. Activity locations were changed in those few instances where a potential environmental or archaeological disturbance was identified.

1.3.2 Scope

Table 1-2 lists the types and number of activities that were performed in the Verification sites. In the Appendix, the geotechnical techniques are discussed in detail. Figure 1-1 lists the number of activities that were performed in each Verification site.

Field work was performed between 19 February and 14 March 1979. The total field time in Arizona during FY 79 was approximately 20 days.

1.4 ANALYSIS OF SUITABLE AREA

The interpretations of suitable area are derived from several sources as explained in the following sections.

OBJECTIVES → VERIFICATION OF INTERMEDIATE/FINE SCREENING S

DATA FOR EVALUATIONS → TERRAIN PARAMETERS | 50'/150' DEPTH TO ROCK

FIELD TECHNIQUES AND APPLICATIONS →

Geologic mapping

- Identification and limits of areas with slopes greater than 10% grade
- Identification and limits of areas with high incidence of 10% slopes (rolling terrain)

Geologic mapping

- Surface limits of rock
- *Subsurface limits of rock* from topographic and geologic interpretation
- Geomorphic expression and erosion history

Seismic refraction surveys

- Subsurface projection of rock limits
- Delineation of rock from high (>=7000 fps) p-wave velocities

Borings

- Occurrence of rock

Gravity profiles (DMA)

- Overall basin shape and relationships
- *Range-bounding faults*

Existing data

- Published literature

1

REENING SUITABLE AREA

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50'–150' DEPTH TO GROUND WATER

Existing data

- Available well records and interpretation

Borings

- Occurrence of ground water

Electrical resistivity/ seismic refraction surveys

- Provide supplemental data to support presence or absence of ground water

Geologic mapping

- Obtain water depths from wells encountered in field

EXTENT AND CHARACTERISTICS OF SOILS

Geologic mapping

- Extent of surficial soil units
- Surficial soil types

Borings

- Identification of subsurface soil types
- In situ soil density and consistency
- Samples for laboratory testing

Trenches, test pits, and surficial samples

- Identification of surface and subsurface soil types
- Degree of induration and cementation of soils
- In situ moisture and density of soils
- Samples for laboratory testing

Cone penetrometer tests

- In situ soil strength

Laboratory tests

- Physical properties
- Engineering properties – shear strength, compressibility
- Chemical properties

GEOPHYSICAL PROPERTIES

Seismic refraction surveys

- Compressional wave velocities

Electrical resistivity surveys

- Electrical conductivity of soils
- Layering of soil

ROAD DES

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Surficial sa

- Identificat
- In situ so moisture
- Thickness o surficial s

Cone penetra

- In situ so
- Thickness o surficial s

Laboratory te

- Physical p
- Compaction
- Suitabilit as road su or base

Existing dat

- Suitabilit as road su or base
- Behavior o

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RISTICS OF BASIN FILL

RECOMMENDATIONS FOR FUTURE VERIFICATION STUDIES

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ROAD DESIGN DATA

Trenches, test pits, and Surficial samples

- Identification of soil types
- In situ soil density and moisture
- Thickness of low-strength surficial soil

Cone penetrometer tests

- *In situ* soil strength
- Thickness of low-strength surficial soils

Laboratory tests

- Physical properties
- Compaction and CBR data
- Suitability of soils for use as road subgrade, subbase or base

Existing data

- Suitability of soils for use as road subgrade, subbase . or base
- Behavior of compacted soils

EXCAVATABILITY AND STABILITY

Borings

- Subsurface soil types
- Presence of cobbles and boulders
- In situ density of subsurface soils
- Stability of vertical walls

Trenches and test pits

- Subsurface soil types
- Subsurface soil density and cementation
- Stability of vertical walls
- Thickness of low-strength surficial soils
- Presence of cobbles and boulders

Laboratory tests

- Physical properties
- Engineering properties

Geologic mapping

- Distribution of soil types

Seismic refaction surveys

- Excavatability

FIELD TECHNIQUES VERIFICATION STUDIES ARIZONA	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	TABLE 1-1

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3

TECHNIQUE	ACTIVITIES		REMARKS	APPENDIX REFERENCE*
	Average Number Per Site	Total for Two Sites		
Geologic Mapping (Stations)	76	153	Reconnaissance mapping performed in Verification sites only	A3.0
Seismic Refraction Measurements	18	35	Seismic refraction survey and electrical resistivity sounding performed in parallel at each location	A4.1
Electrical Resistivity Soundings	16	33		A4.2
Gravity Surveys	**	**	Field surveys to be performed by Defense Mapping Agency (DMATC)	A4.3
Borings	6	11	Rotary wash to 160 feet	A5.1
Trenches and Test Pits	5 26	10 53	Excavated with a backhoe	A5.2
Cone Penetrometer Tests (CPT)	66	133	Truck-mounted, electronic	A5.3
Laboratory Tests	-	-	See CDP sections for listing of lab tests	A5.6

Notes: * Detailed descriptions of these tasks are included in the specified Appendix.

** Data not available for this report

GEOTECHNICAL ACTIVITIES
VERIFICATION STUDIES
ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 1-2

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1.4.1 Depth to Rock

In the Verification sites, 50- and 150-foot depth to rock contours were estimated and are shown on the Depth to Rock maps of the La Posa and Butl-r CDPs. The locations of the contours are based on the limited boring and geophysical data in combination with geologic interpretation. The interpretation considers the presence or absence of range-bounding faults, bedding plane attitudes, evidence of erosional features such as pediments, and the presence or absence of young volcanic rocks.

1.4.2 Depth to Water

Ground-water contours are based on published well-point data most of which is fairly recent. The density of data is variable and only where there is a good density of data can ground-water contours be drawn with a relatively high degree of confidence. The limited number of borings and geophysical surveys conducted during the Verification studies did not encounter evidence of shallow ground water to the depths investigated.

1.4.3 Terrain

During screening studies, areas were excluded because of unsuitable terrain. The major exclusion criterion was a maximum permissible grade of 10 percent. Existing topographic maps do not show terrain conditions with sufficient detail to make an accurate evaluation of suitability.

To provide preliminary information about terrain conditions, terrain maps have been produced and are presented in the individual CDP discussions. These "interpretive" maps are based

on an evaluation of existing maps, field observations, and the distribution of geologic units. They will provide the reader with a preliminary assessment of terrain conditions prior to the production of more detailed topographic maps.

1.5 ANALYSES OF BASIN-FILL CHARACTERISTICS

In addition to the primary objective of refining the boundaries of suitable areas, a secondary objective was to provide preliminary physical and engineering properties of the basin-fill materials. These data will be used for preliminary engineering design studies, will assist in planning future site-specific studies, and will be used by other MX participants.

The scope of activities to define engineering properties has been designed primarily to obtain information needed for construction activities. Particular emphasis has been placed on the surficial soil conditions as related to road construction, a major cost item. Moderate emphasis has been placed on soil conditions in the upper 20 feet (6 m) since this would be the approximate depth of excavation for the trench or horizontal shelter concept. Limited data have been obtained from borings drilled to a depth of 160 feet (49 m), which is the depth of interest for the vertical shelter basing mode. The spread on seismic refraction lines was also designed to obtain information to 150-foot (46-m) depth.

To assist in determining the distribution of surficial soils, a surficial geologic map has been prepared. It is based on the interpretation of aerial photos and field mapping. Other

data used to define surficial soil conditions include surficial soil samples, test pits, trenches, and cone penetrometer tests. Samples obtained at these activity locations were tested in the laboratory to determine physical and engineering properties. The cone penetrometer tests provided a means of measuring in-situ soil properties.

Data obtained from test pits, trenches, borings, seismic refraction lines, and laboratory tests were used to estimate soil properties to a depth of 20 feet (6 m). Since most test pits were excavated to a depth of only 5 feet (1.5 m), the amount of data collected below a depth of 5 feet is, typically, limited to that obtained from five trenches and five to six borings. These ten to 11 data points represent a very small percentage of the total area in a typical Verification site (300 mi^2; 780 km^2). Thus, the range of properties presented in the report may be subject to revision.

In discussing the soil parameters between a depth of 20 and 160 feet (6 and 49 m), the data are limited to that obtained from the five to six borings that were drilled within each Verification site. Considering that the typical spacing between borings was 5 to 7 miles (8 to 11 km), the data presented should not necessarily be considered as representative of an entire CDP.

1.6 REPORT ORGANIZATION AND DATA PRESENTATION

1.6.1 Report Organization

Results of the Verification studies in the Arizona study area are contained in two volumes.

Volume I. Sections 1.0 and 2.0 contain Introduction and Results and Conclusions; Sections 3.0 and 4.0 contain summary geotechnical data for La Posa and Butler CDPs, respectively. Specific topics included within Sections 3.0 and 4.0 are:

- o Geographic Setting
- o Scope (of site studies)
- o Geologic Setting
- o Surface Soils (Characterization)
- o Subsurface Soils (Characterization)
- o Terrain
- o Depth to Rock
- o Depth to Water
- o Results and Conclusions (Suitable Area and Construction Considerations)

The Appendix included with Volume 1 contains a glossary of terms, exclusion criteria, and details of the field and office techniques used in the Verification program.

Volume 1 also contains detailed geotechnical data for the La Posa CDP.

Volume II. This volume contains detailed geotechnical data for Butler CDP. It is similar to the data for La Posa CDP which is included in Volume 1. The geotechnical data sections contain detailed logs of all the field and laboratory activities pertaining to the CDP.

1.6.2 Data Presentation

1.6.2.1 Maps

A suitable area map (Drawing 2-1 in pocket) for the Arizona study area is presented in Section 2.0. It shows the suitable area for the hybrid trench and vertical shelter basing modes as determined from FY 79 Verification field studies.

In Volume I, Sections 3.0 and 4.0 contain six maps that display the pertinent data for each Verification site. All of these foldout maps are at a scale of 1:125,000. The order in which these maps appear is listed below and includes the drawing number (the X should be replaced by the appropriate Section number).

- o Activity Locations - Drawing X-1
- o Surficial Geologic Units - Drawing X-2
- o Terrain - Drawing X-3
- o Depth to Rock - Drawing X-4
- o Depth to Water - Drawing X-5
- o Suitable Area, Hybrid Trench and Vertical Shelter - Drawing X-6

Drawings X-3, X-4, and X-5 present the data which were used to determine the boundaries of the suitable area shown in Drawing X-6.

1.6.2.2 Tables and Figures

Most of the tables and figures are included in the individual CDP sections. The following tables are included in each:

- o Scope of Activities - Table X-1
- o Characteristics of Surficial Soils - Table X-2
- o Thickness of Low-Strength Surficial Soil - Table X-3
- o Seismic Refraction and Electrical Resistivity - Table X-4
- o Characteristics of Subsurface Soils - Table X-5

The figures in each CDP section include a location map of the Verification site, plots showing range in gradation of soils, and soil profiles.

2.0 RESULTS AND CONCLUSIONS

2.1 SUITABLE AREA

At the start of the FY 79 Verification program, 318 mi^2 in the La Posa site and 311 mi^2 in the Butler site (827 and 809 km^2) were considered to be suitable based on the earlier Screening studies. At the completion of the Verification studies, the estimates of suitable area in the two sites were revised as follows:

FY 79 SUITABLE AREA

Verification Site	Trench mi^2 (km2)	Vertical Shelter mi^2 (km2)
La Posa	300 (775)	230 (600)
Butler	245 (640)	225 (585)

These estimates are based on interpretations of suitable area compiled on maps at a scale of 1:125,000. The boundaries of the suitable area were digitized and inputted to a computer program to calculate the area within the boundaries.

The total suitable area in the Arizona study area, as shown in Drawing 2-1, encompasses approximately 10,410 mi^2 (26,962 km^2). Estimates of the suitable area covered in the Screening, Characterization, Methodology and Verification studies are provided in Table 2-1.

The earlier Methodology studies were based on extensive geologic mapping, similar to the Verification studies. However, since Screening and Characterization studies were based heavily on literature and reconnaissance-level geologic mapping surveys,

PROGRAM	SITE	HYBRID TRENCH (1) mi^2 (km^2)	VERTICAL SHELTER mi^2 (km^2)
METHODOLOGY STUDIES FY 77	MOHAWK-TULE LECHUGUILLA SAN CRISTOBAL	220 (570) 430 (1114) 470 (1217)	(2)
CHARACTERIZATION STUDIES FY 78	SACRAMENTO RANEGRAS AGUILA	660 (1709) 710 (1839) 830 (2150)	(2)
VERIFICATION STUDIES FY 79	LA POSA BUTLER	300 (777) 245 (635)	230 (600) 225 (585)
	TOTAL	3865 (10,010)	

REMAINING SUITABLE AREA FROM SCREENING STUDIES FY 79	6545 (16,952)
TOTAL	10,410 (26,962)

NOTES: (1) ALSO APPLICABLE FOR HORIZONTAL SHELTER
(2) AREA NOT DETERMINED FOR THESE SITES

ESTIMATED SUITABLE AREA
FY 79 VERIFICATION STUDIES
ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 2-1

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respectively, changes in suitable area can be expected in those areas. Changes in suitable area could also ocur in those areas where field investigations have been made if more studies are performed to refine rock and water contours.

All criteria applied to determine suitable area are listed in the Appendix, Section A2.0. The three major criteria which have affected suitable area boundaries are:

- o 50 and 150 feet to rock;
- o 50 and 150 feet to water; and
- o adverse terrain.

2.1.1 Depth to Rock

In determining suitable area based on depth to rock, the following approach has been used. In the Verification sites, limited subsurface information has been obtained and 50- and 150-foot (15- and 46-m) depth to rock contours have been interpreted. Studies in the two Verification sites have indicated that loss of suitable area resulting from using the 50- or 150-foot depth to rock contours instead of the exposed rock contact is variable, ranging from 10 to 18 percent of the total area studied as shown in the following table:

	La Posa	Butler
50' rock reduction	10%	13%
150' rock reduction	14%	18%

In determining the location of rock contours in Verification sites, the decision was made to select contours that reflect projected depths to rock comparable to that exposed in the

adjacent mountains. A seismic velocity greater than 7000 fps (2134 mps) was not always used to define bedrock although it was stated as a criterion in previous studies. It was discovered that in a few instances soil-like materials have seismic velocities between 7000 and 9000 fps (2134 and 2745 mps). Seismic velocities were used as definite indicators of rock when velocities were greater than 9000 fps.

In most cases, contours closely parallel the rock/alluvium contacts. In areas of low relief rock and areas typified by erosional morphology (pediments, embayed reentrants and rock outliers), contours were more widely spaced to provide a more conservative estimate of suitable area.

Some changes in suitable area based on depth to rock can be expected as more field data are collected (if future field studies are undertaken).

2.1.2 Depth to Ground Water

With the addition of data obtained in this study, the configuration of ground-water contours changed slightly from previous Screening studies. For the most part, the contours were slightly modified but this did not account for appreciable net area changes. This is especially true for the trench basing mode (50 feet; 15 m) in the La Posa site.

Sources and pertinent information regarding the data used to compile the depth to water maps are located in Section 2.0 of Geotechnical Data for each CDP.

2.1.3 Terrain

As could be expected, 1:62,500- and 1:24,000-scale topographic maps did not have satisfactory resolution for the necessary terrain evaluations (primarily drainage depth measurements). Therefore, decisions regarding terrain suitability have been based primarily on aerial photo interpretations and field observations. The terrain criterion has had the greatest impact on the loss of suitable area during the Verification program, especially in the Butler site.

2.2 BASIN-FILL CHARACTERISTICS

2.2.1 General

Generalized characteristics of the soils in the Verification sites are summarized in this section. They include soil types, their physical and engineering properties, and strength characteristics of surficial soils to provide information for preliminary road design.

2.2.2 Surficial Soils

Surface soils are predominantly coarse-grained (granular) consisting of sands and gravels. Fine-grained soils (silts and clays) exist over limited portions of both sites. Gravels and gravelly sands are the predominant surficial soils of the La Posa Site, covering most of the southern two-thirds. Sands, generally coarse to fine, are randomly distributed throughout southern La Posa. Northern La Posa is covered by uniform, poorly graded, fine to medium sands of eolian origin. Silts and

clays are least common and occur as random pockets in coarse-grained alluvial fan deposits.

Sands, silty sands, and clayey sands are the predominant surficial soils in the Butler site. Most sands are graded coarse to fine and contain gravel traces; however, uniform, fine to medium eolian sands are randomly distributed through western Butler. Gravels and gravelly sands are generally restricted to alluvial fans near mountain fronts. Silts and clays are least common, occurring as isolated pockets in coarse-grained alluvial fan deposits and in eastern Butler as exposed clay beds in older lacustrine deposits.

2.2.2.1 Low-Strength Surficial Soil

Analysis of the results of cone penetrometer tests (CPTs) in conjunction with the results of other engineering activities revealed that "low-strength" surficial soil, which will perform poorly as a road subgrade at its present consistency, exists in both sites. Criteria were developed during the Nevada-Utah Verification studies to define low-strength soil using CPT results (see Section A5.7 in Appendix for details). Using these criteria, the extent of low-strength surficial soil in both sites was estimated. The coarse-grained soils exhibit low strengths to depths ranging from 0.3 to 10.9 feet (0.1 to 3.3 m) with an average of 3.4 feet (1.0 m) below ground surface. The fine-grained soils exhibit low strengths to depths ranging from 0.3 to 4.2 feet (0.1 to 1.3 m) with an average of 1.9 feet (0.6 m).

2.2.2.2 Subgrade Support Strength

Results of laboratory California Bearing Ratio (CBR) tests on surficial samples from the Nevada-Utah and Arizona sites indicate that compacted coarse-grained soils will generally exhibit moderate (CBR=15 to 30) to high (CBR>30) CBR values depending on amounts of gravels and fines in the soil. Exceptions were uniformly graded eolian sands of the La Posa site with low (<15) CBR values. Fine-grained soils generally exhibit low (<15) CBR values. Correlation between laboratory CBR and percent fines for all sites (see Section A5.7 in Appendix for details) indicates that CBR values for coarse-grained soils increase with an increase in percent fines up to a certain limit and then decrease gradually. Using this correlation, laboratory CBR values of a soil can be estimated.

2.2.3 Subsurface Soils

Soils in the subsurface are predominantly coarse-grained, consisting of sandy gravels, gravelly sands, sands, silty sands, and clayey sands. Fine-grained soils (silts and clays) are generally restricted to localized lenses in terrace or alluvial fan deposits.

The coarse-grained soils are generally dense to very dense below depths of 10 to 20 feet (3 to 6 m), are mostly poorly graded, exhibit low compressibilities, and possess moderate to high shear strengths. The fine-grained soils exhibit low to high plasticity and generally contain appreciable amounts of fine

sand. Intermittent calcium carbonate cementation exists in the subsurface soils.

The soils in the construction zone (120 feet; 37 m) have a wide range of seismic velocities (1130 to 9350 fps; 344 to 2850 mps), depending on their composition, consistency, and cementation. Soils in the upper 50 feet (15 m) may have electrical conductivities ranging from 0.0019 to 0.0487 mhos per meter (Fine Screening criteria; electrical conductivity of soil should be greater than 0.004 mhos per meter). Soils with conductivities below the Fine Screening criteria minimum were encountered in northern La Posa. Chemical test results indicate that potential for sulfate attack of soils on concrete will range from "negligible" to "considerable."

2.2.4 Construction Considerations

In this section, geotechnical factors and conditions which would affect the construction of the MX system, both hybrid trench and vertical shelter concepts, are discussed.

2.2.4.1 Roads

The surficial soils in the Verification sites are predominantly coarse-grained. In a dense state, these soils provide good subgrade support for roads. However, most of these soils consist of alluvial or eolian deposits that are not well compacted near the surface. The thickness of these low-strength surficial soils ranges from a few inches to several feet, the average being about 3.4 feet (1.0 m). In this condition, the materials will not provide adequate support for heavy wheel loads. These

granular soils can be recompacted to a higher density and will then provide very good support. In localized areas, the surficial soil may consist of a fine-grained deposit which is only a few feet thick; in this case, the weak material could be removed and replaced with a granular material. In a few areas, such as playas, there may be a relatively thick layer of weak, fine-grained soil which has low bearing strength even if compacted to a high density. In these areas, either a thick section of subbase and base course or soil stabilization techniques will be necessary.

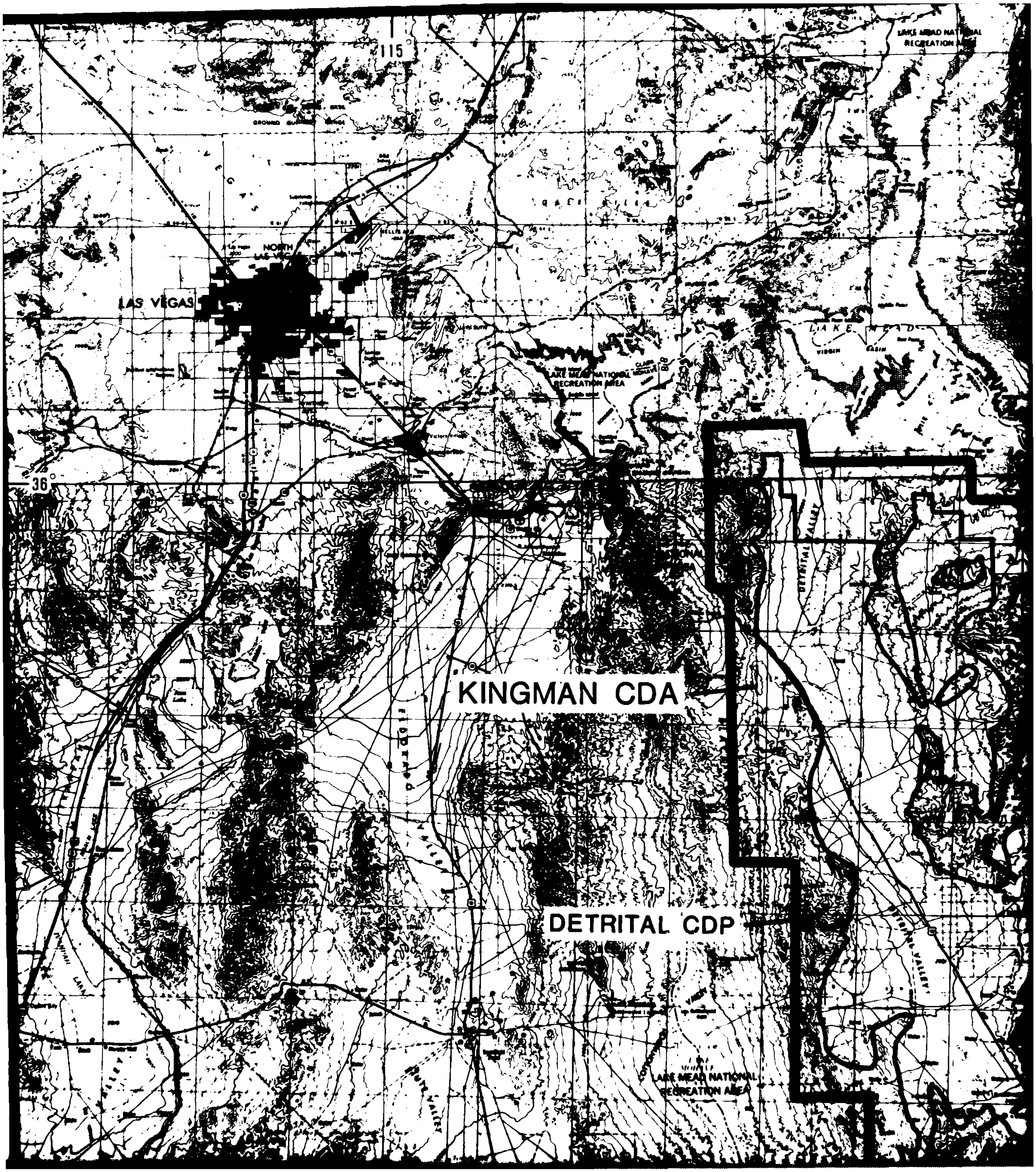
The studies in the Verification sites do indicate that there are significant quantities of sands and gravels with a wide range of particle sizes which can be used for road subbase and base course. Soils with less than 15 to 25 percent fines could be used for subbase material in the natural state. Processing will generally be required to meet standard specifications for base course.

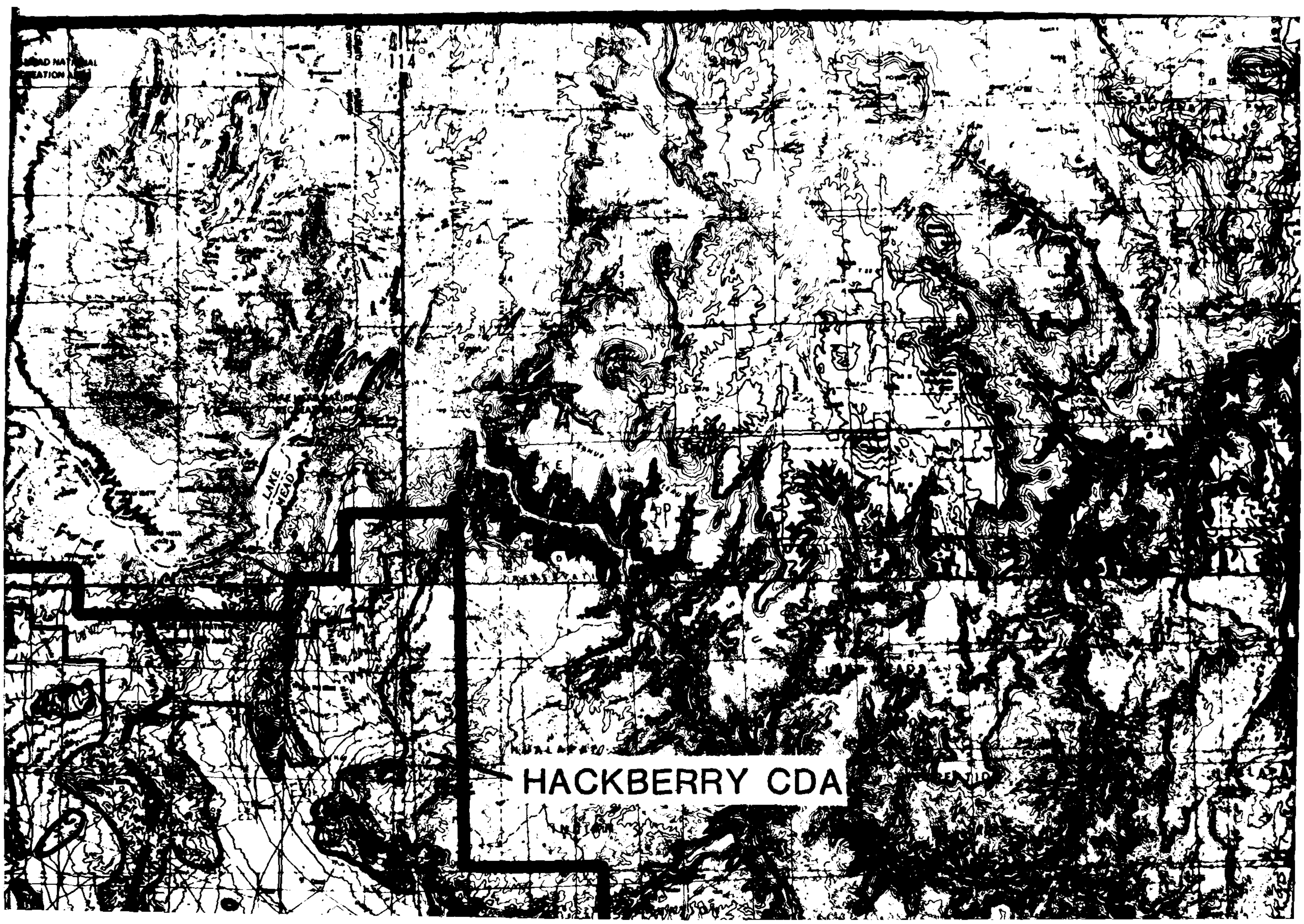
2.2.4.2 Excavatability and Stability

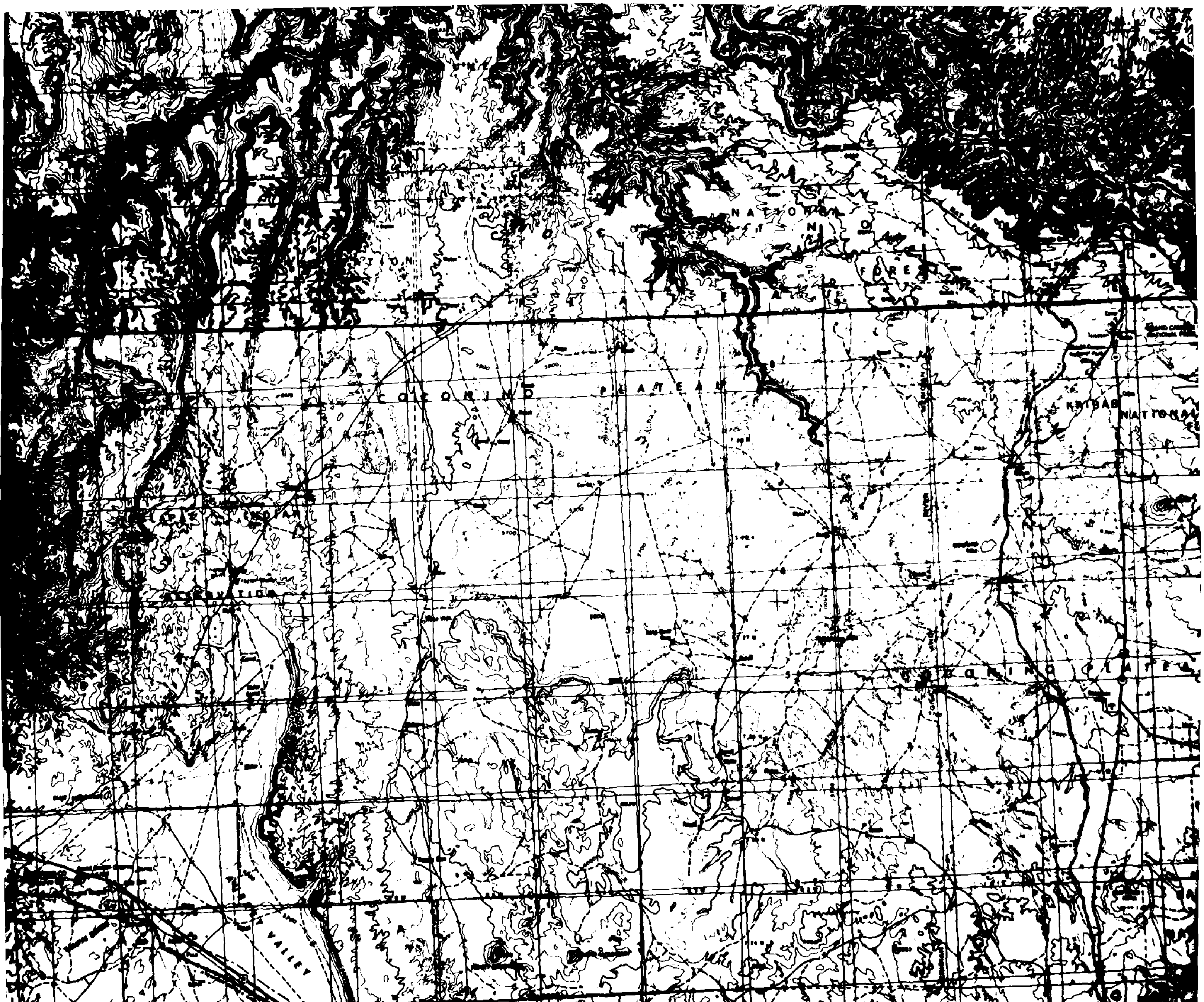
Hybrid trench: Within the depth of excavation for the hybrid trench, compressional wave velocities and observations made during backhoe excavations indicate easy to moderately difficult excavation. An MX trencher could be used for excavating continuous trenches suitable for cast-in-place construction. Soils within the low-strength surficial interval will generally have to be sloped back for stability. Below this weak surface layer, vertical walls will generally be temporarily stable in a

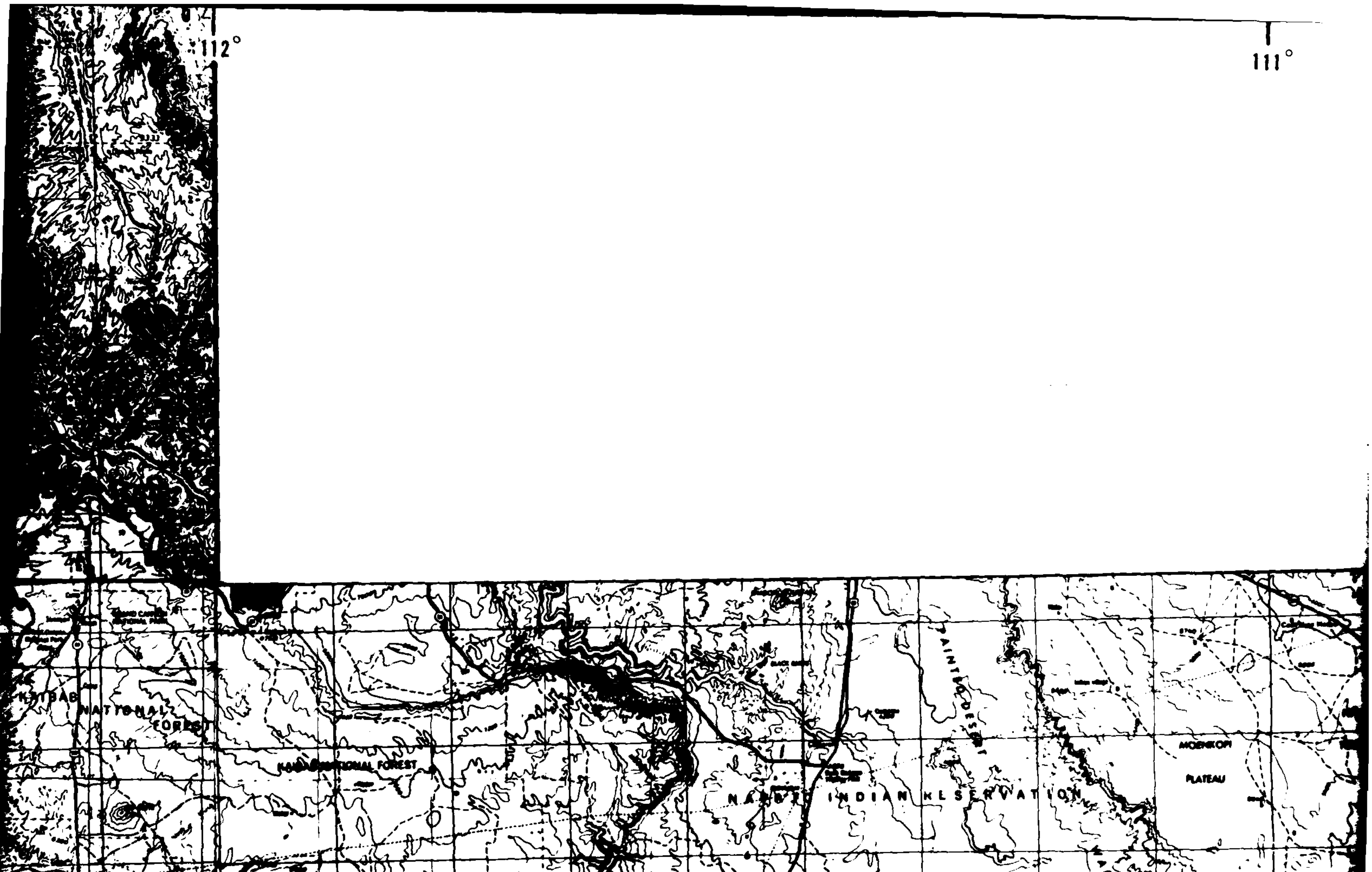
major portion of the site areas. In the remaining area, the trench walls will have to be supported or sloped back for stability.

Vertical shelter: The results of our investigation indicate that conventional excavation equipment or large diameter augers could be used for excavation of the vertical shelters. Most of the excavations will be in coarse-grained soils with only intermittent cemented zones or cohesive soils. Therefore, shaft walls will generally require support.


115
LAKE MEAD NATIONAL RECREATION AREA
LAS VEGAS
NORTH LAS VEGAS
LAKE MEAD
LAKE MEAD NATIONAL RECREATION AREA
36
KINGMAN CDA
DETRITAL CDP
LAKE MEAD NATIONAL RECREATION AREA

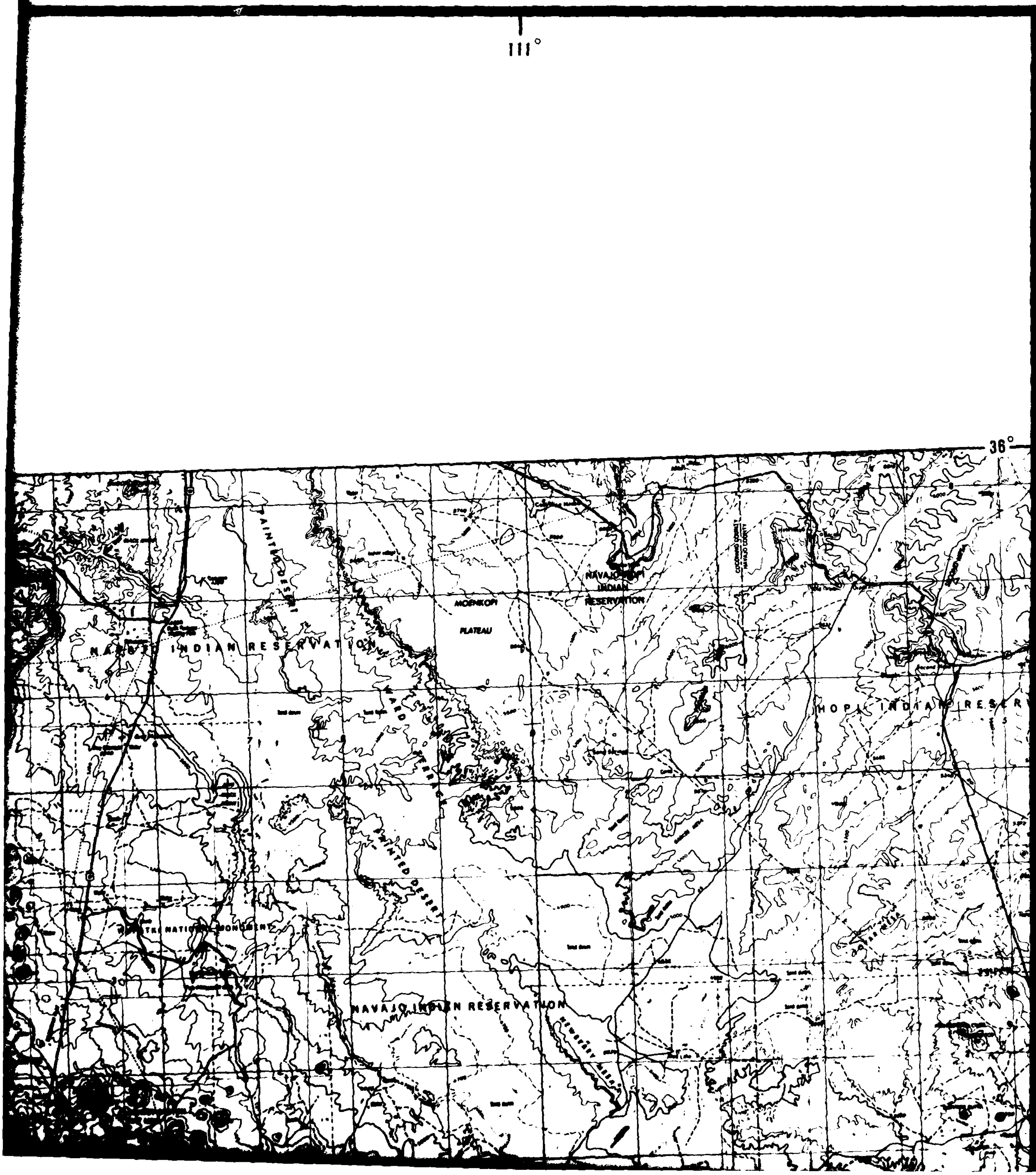

HACKBERRY CDA
LAKE MEAD


PLATEAU
VALLEY

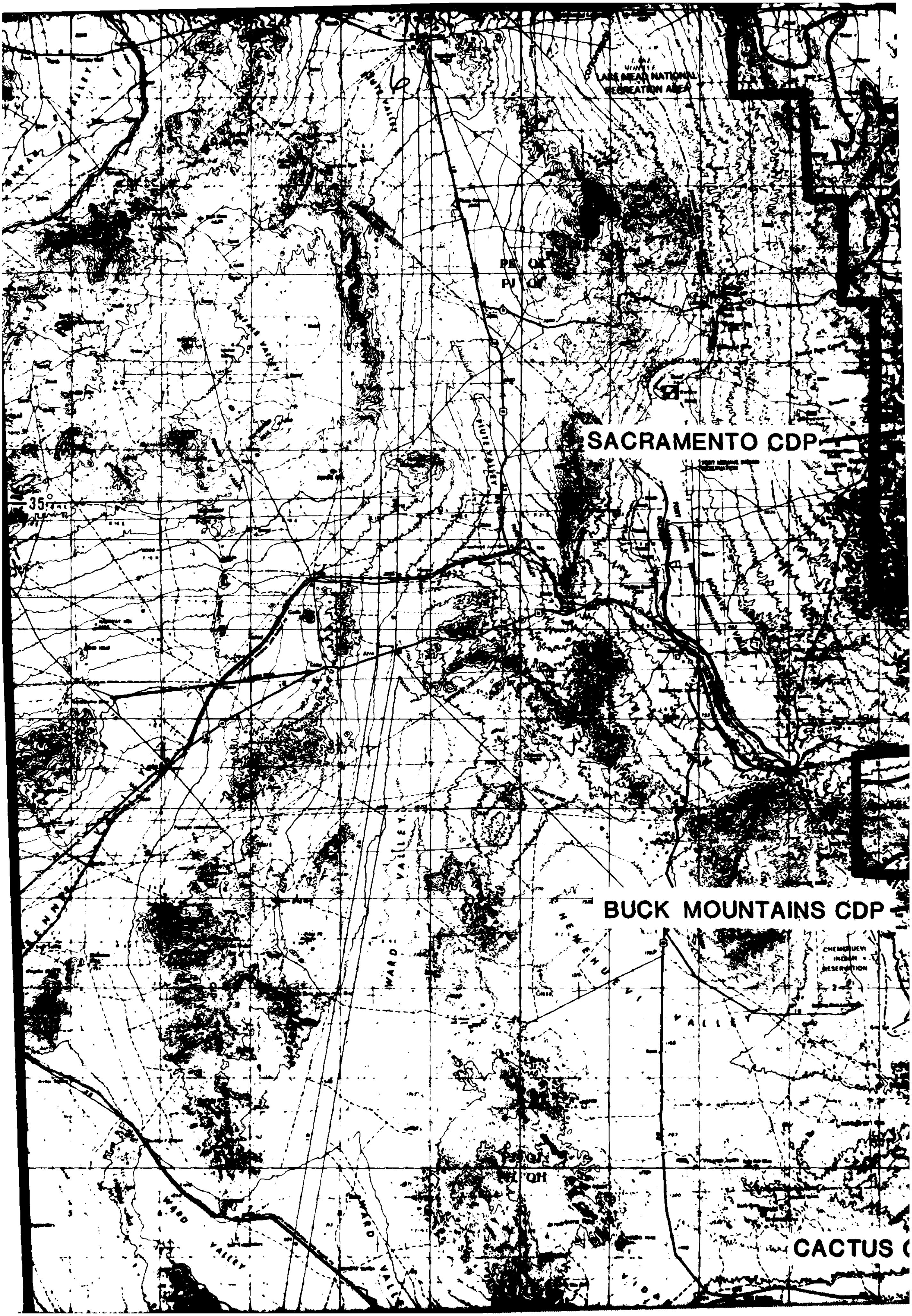


112°
111°
MOENKOPI
PLATEAU
NAVAJO INDIAN RESERVATION
PAINTED DESERT

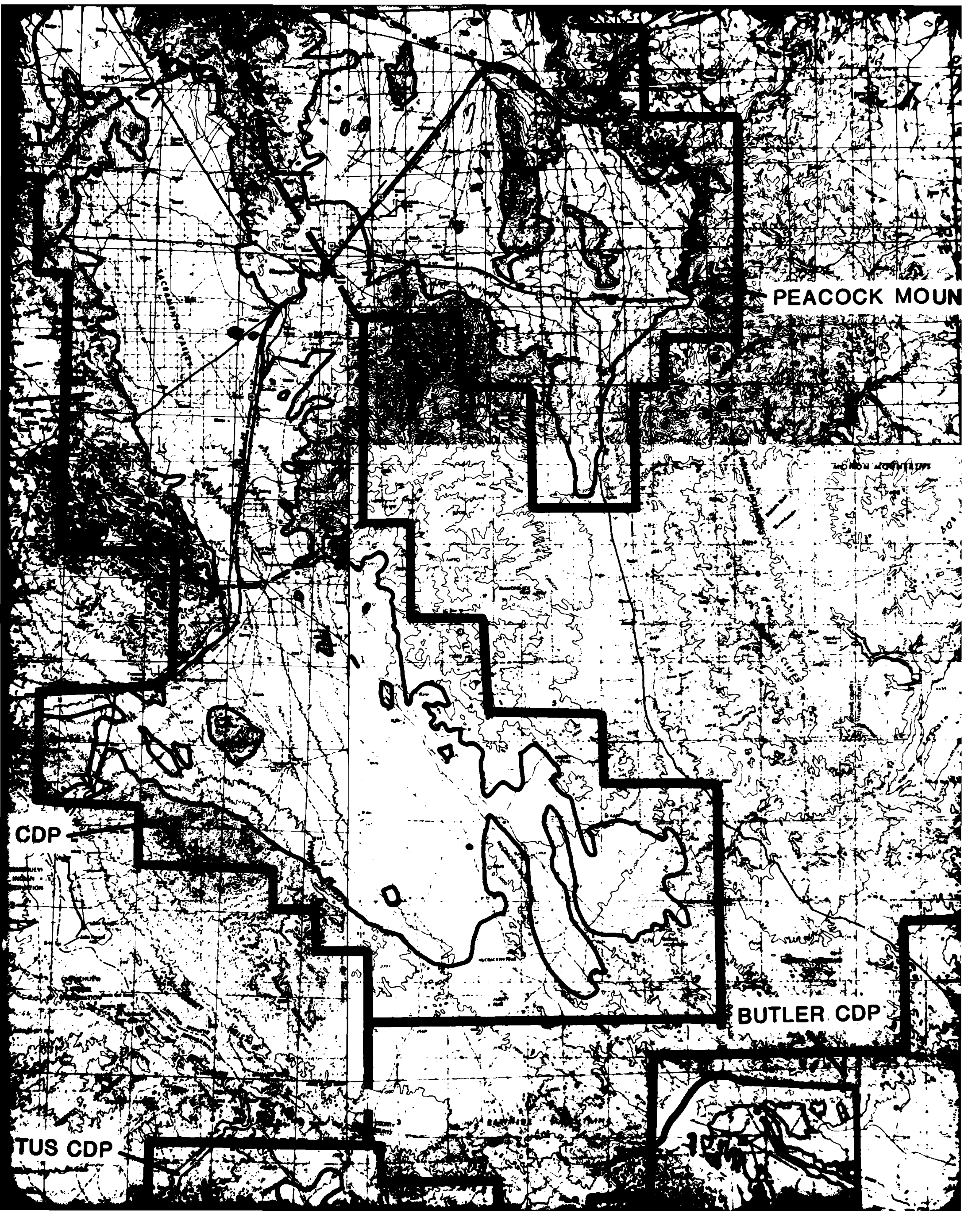
4 1 5



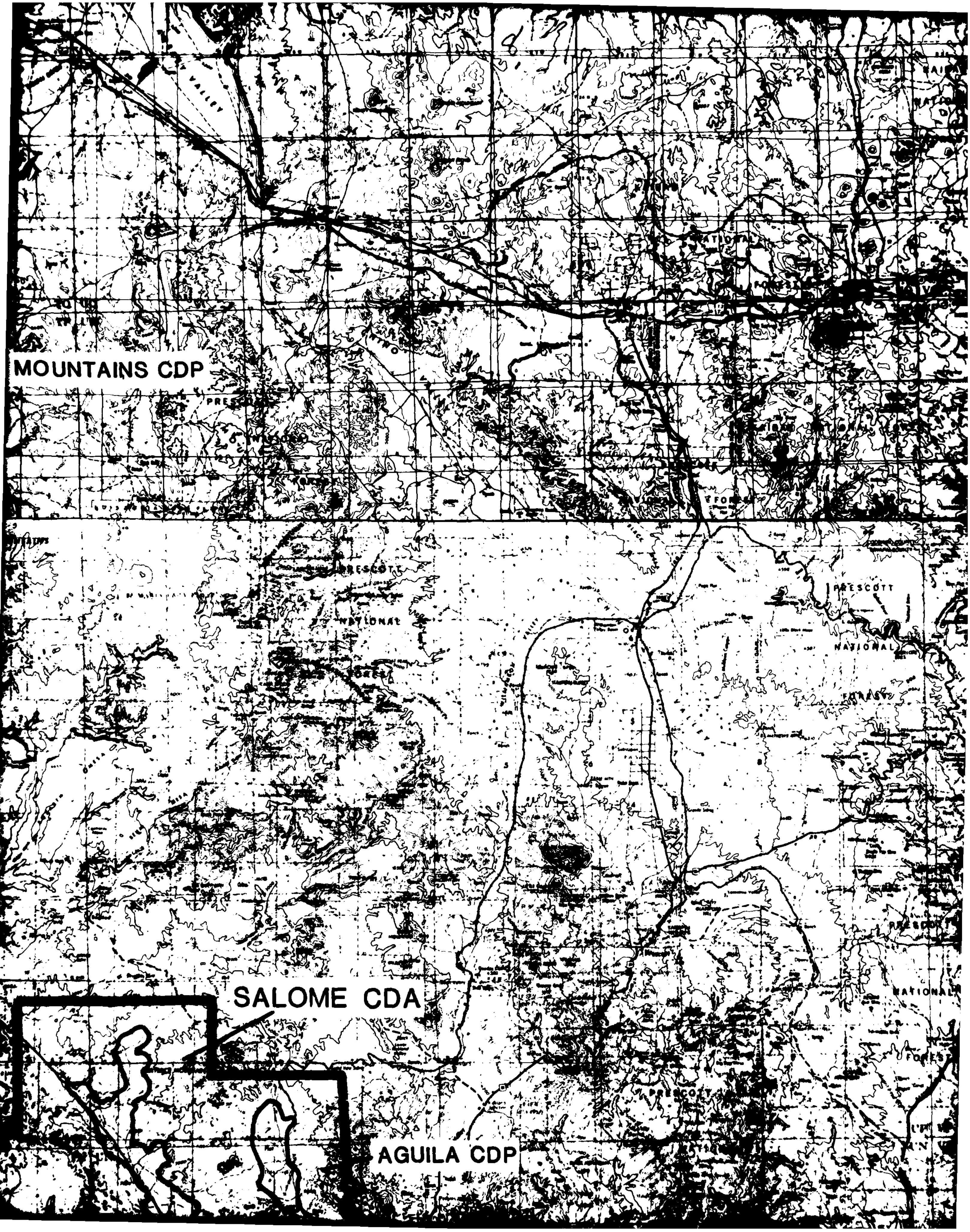
111°
36°
NAVAJO-HOPI INDIAN RESERVATION
MOENKOPI
PLATEAU
NAVAJO INDIAN RESERVATION
PAINTED DESERT
WARD TERRACE
HOPI INDIAN RESERV
NAVAJO INDIAN RESERVATION



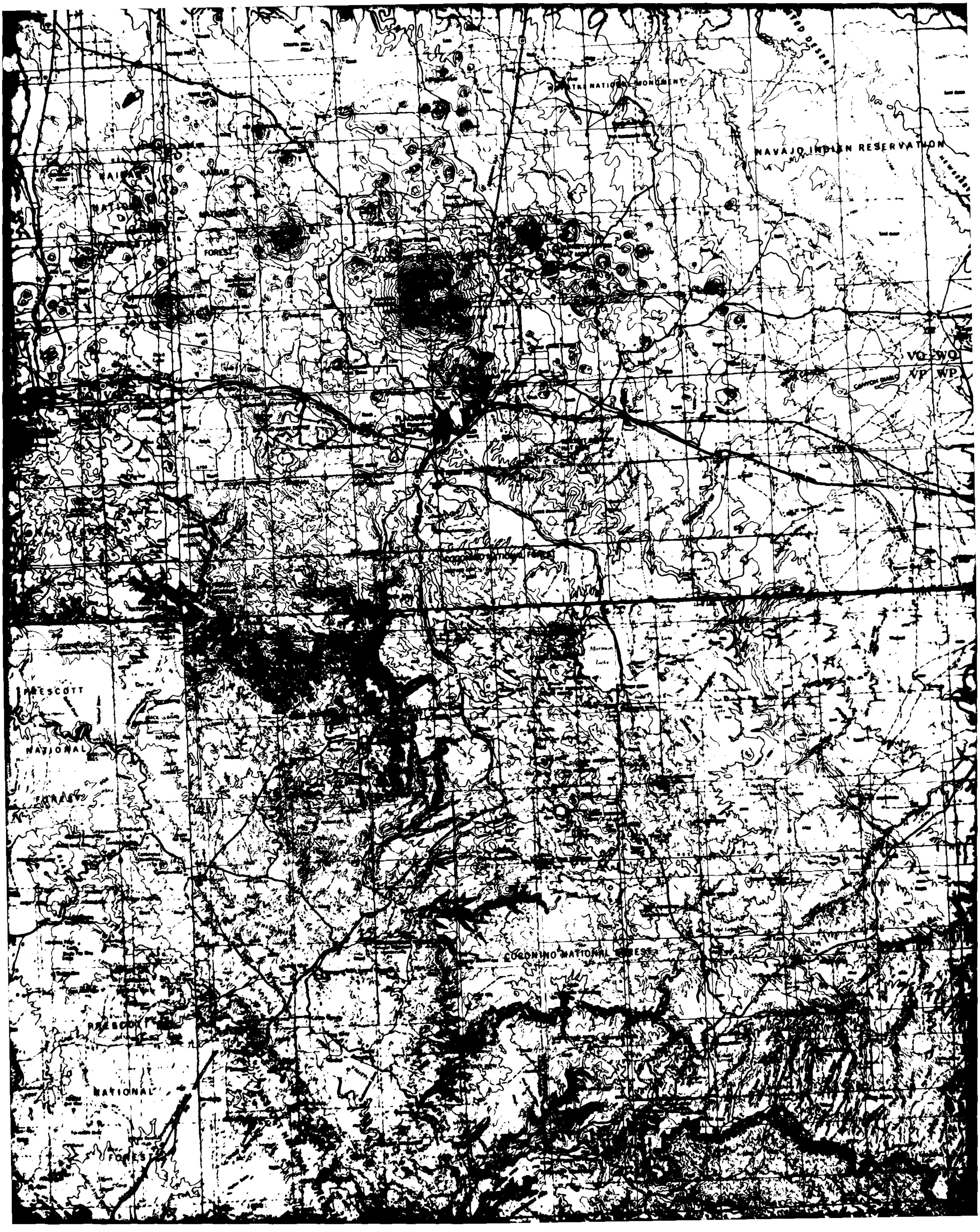
LAKE MEAD NATIONAL RECREATION AREA
SACRAMENTO CDP
BUCK MOUNTAINS CDP
CACTUS C
CHEMEHUEVI INDIAN RESERVATION
WARD VALLEY
35°

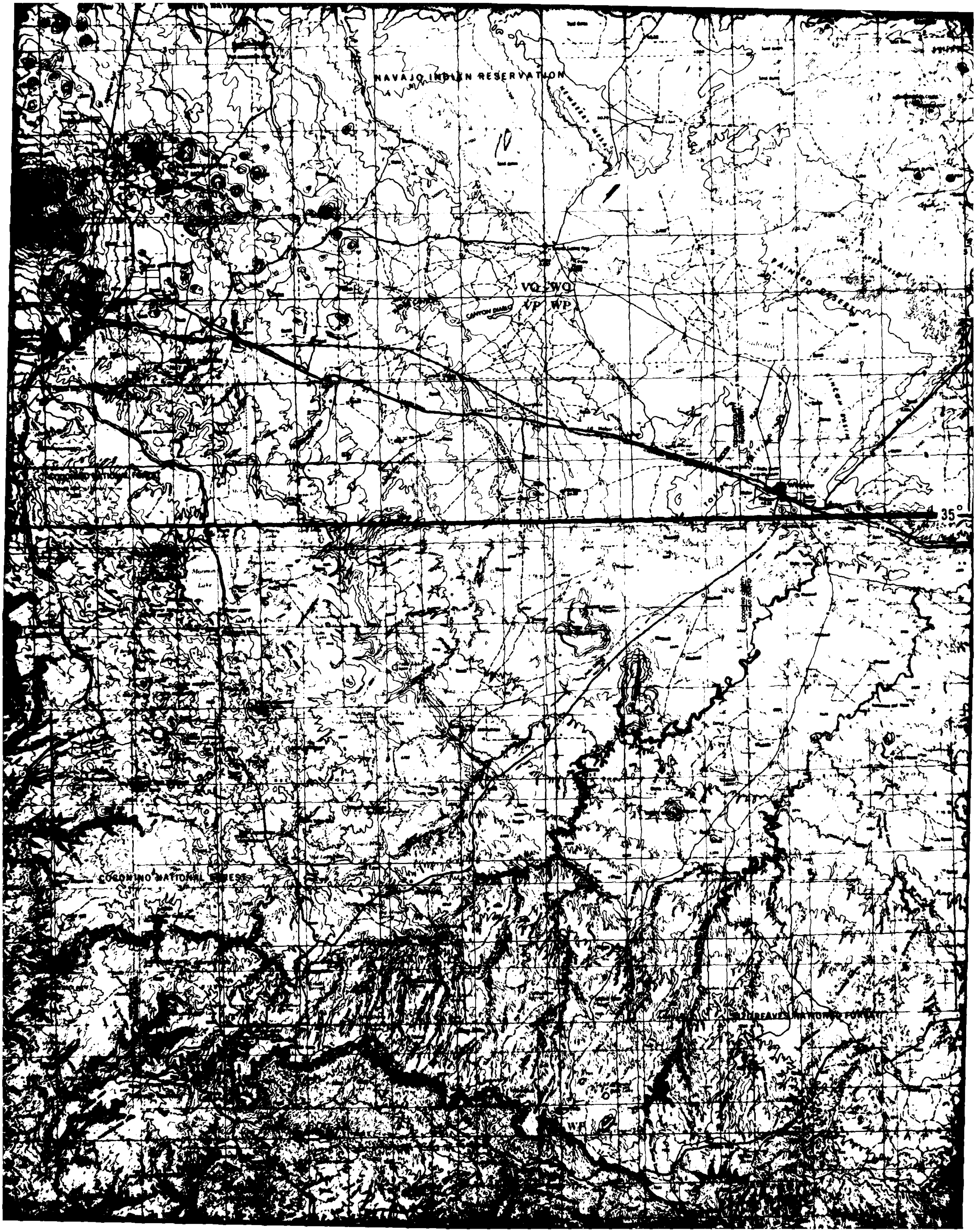


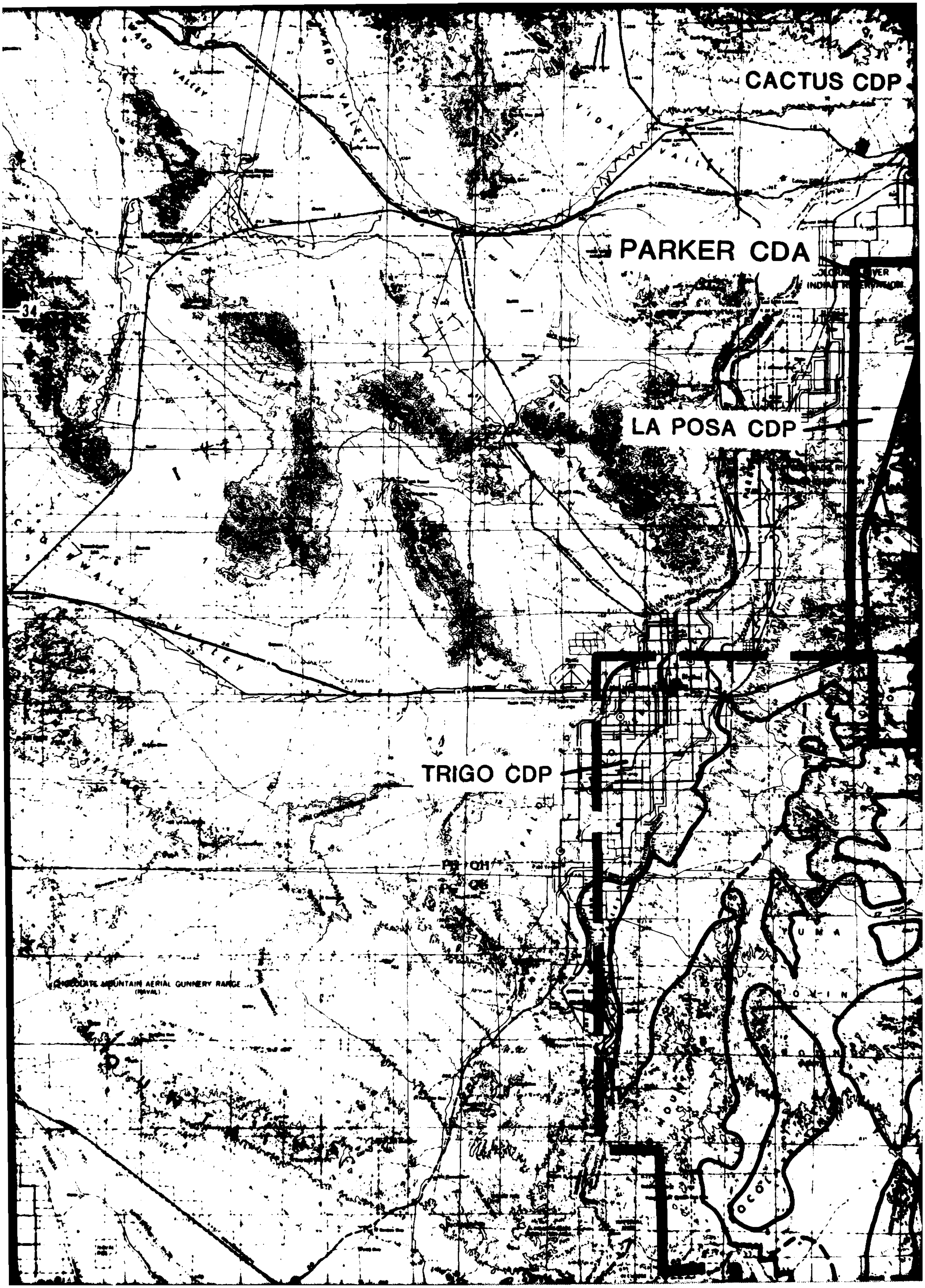
PEACOCK MOUN
CDP
BUTLER CDP
TUS CDP



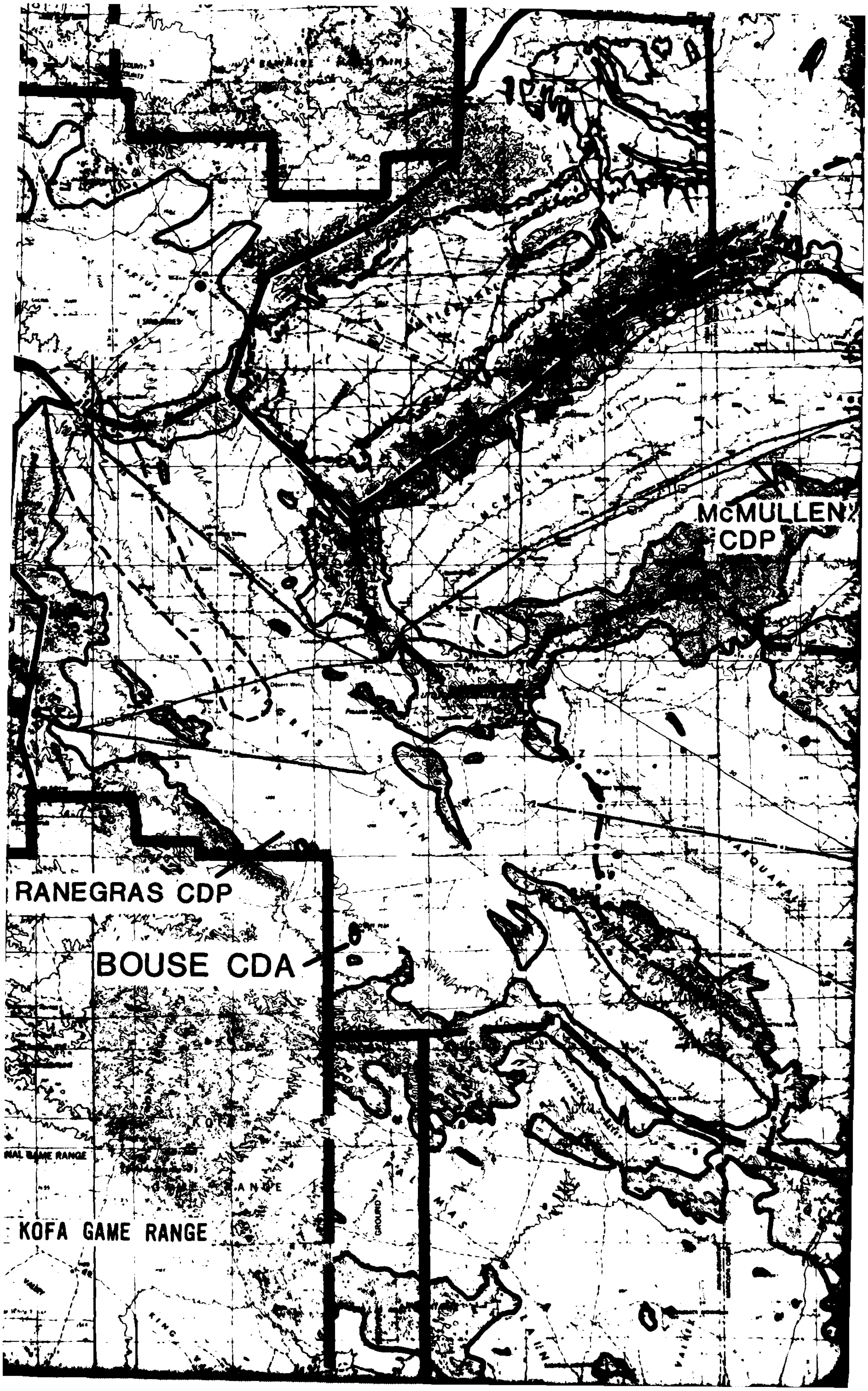
MOUNTAINS CDP
SALOME CDA
AGUILA CDP
PRESCOTT
NATIONAL
FOREST
VALLEY


NAVAJO INDIAN RESERVATION
PRESCOTT
NATIONAL
FOREST
COCONINO NATIONAL FOREST
VQ WQ
VP WP

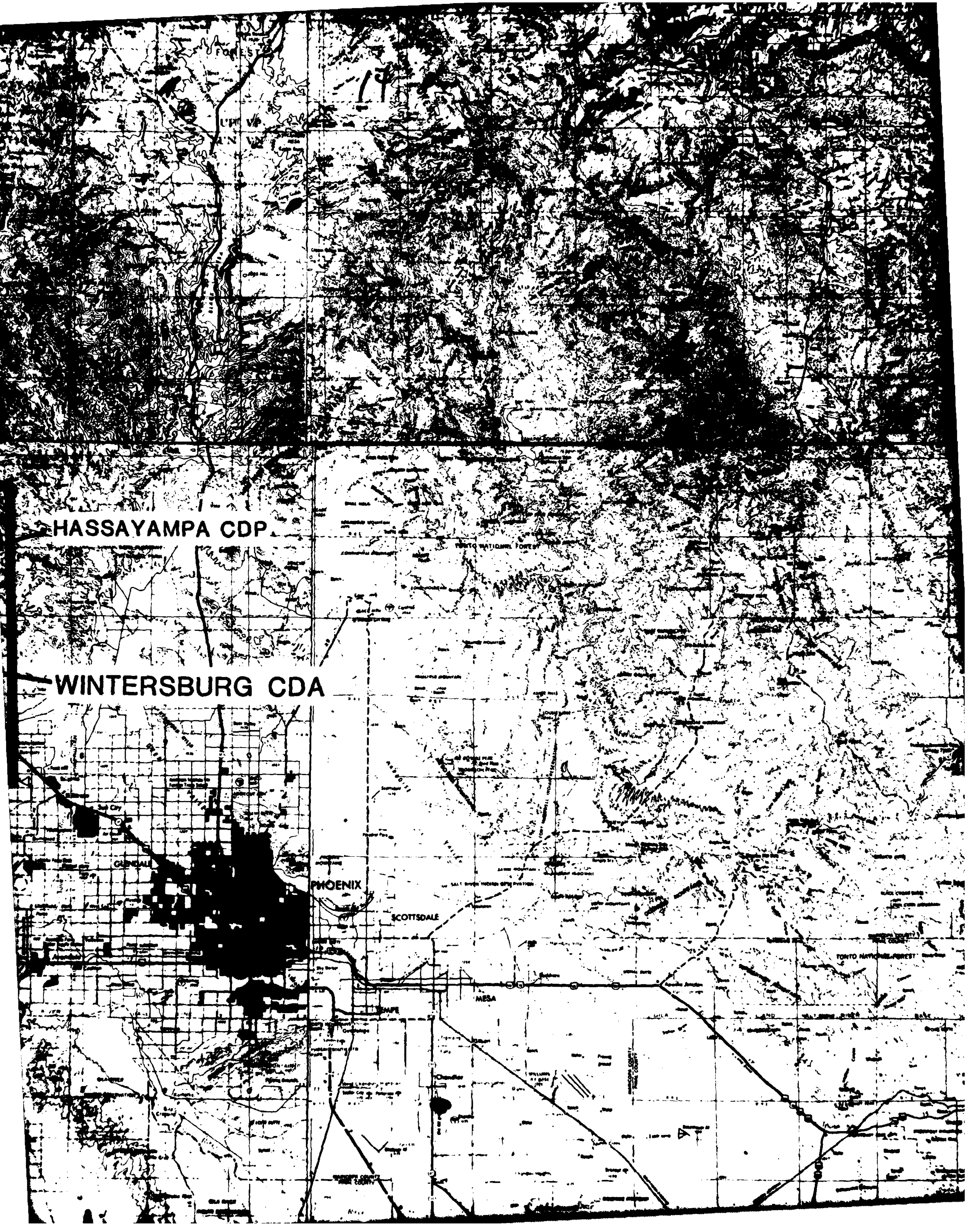

NAVAJO INDIAN RESERVATION
VQ WQ
VP WP
CANYON DIABLO
PAINTED DESERT
35°
Mormon Lake
COCONINO NATIONAL FOREST
SITGREAVES NATIONAL FOREST
WR

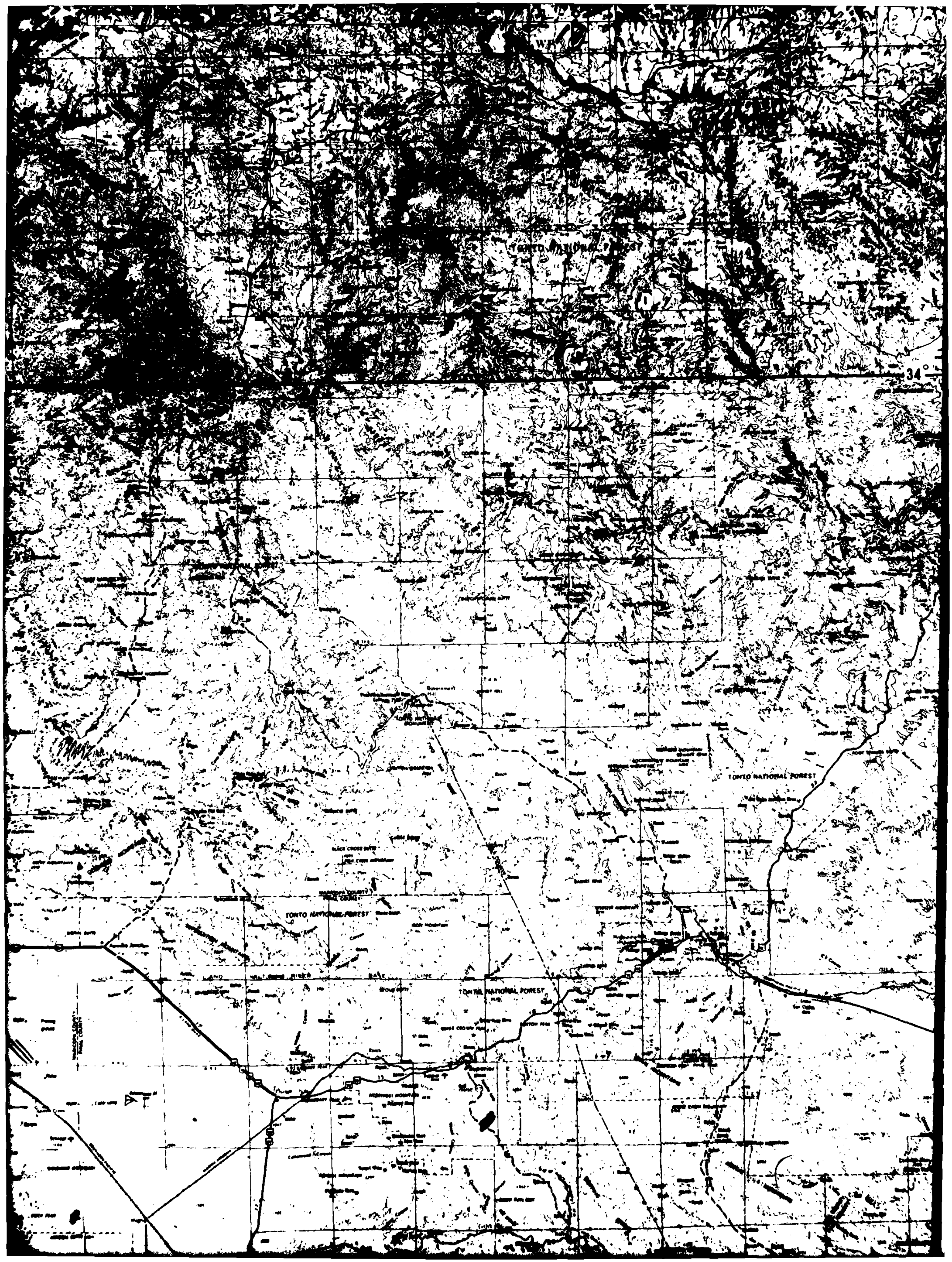


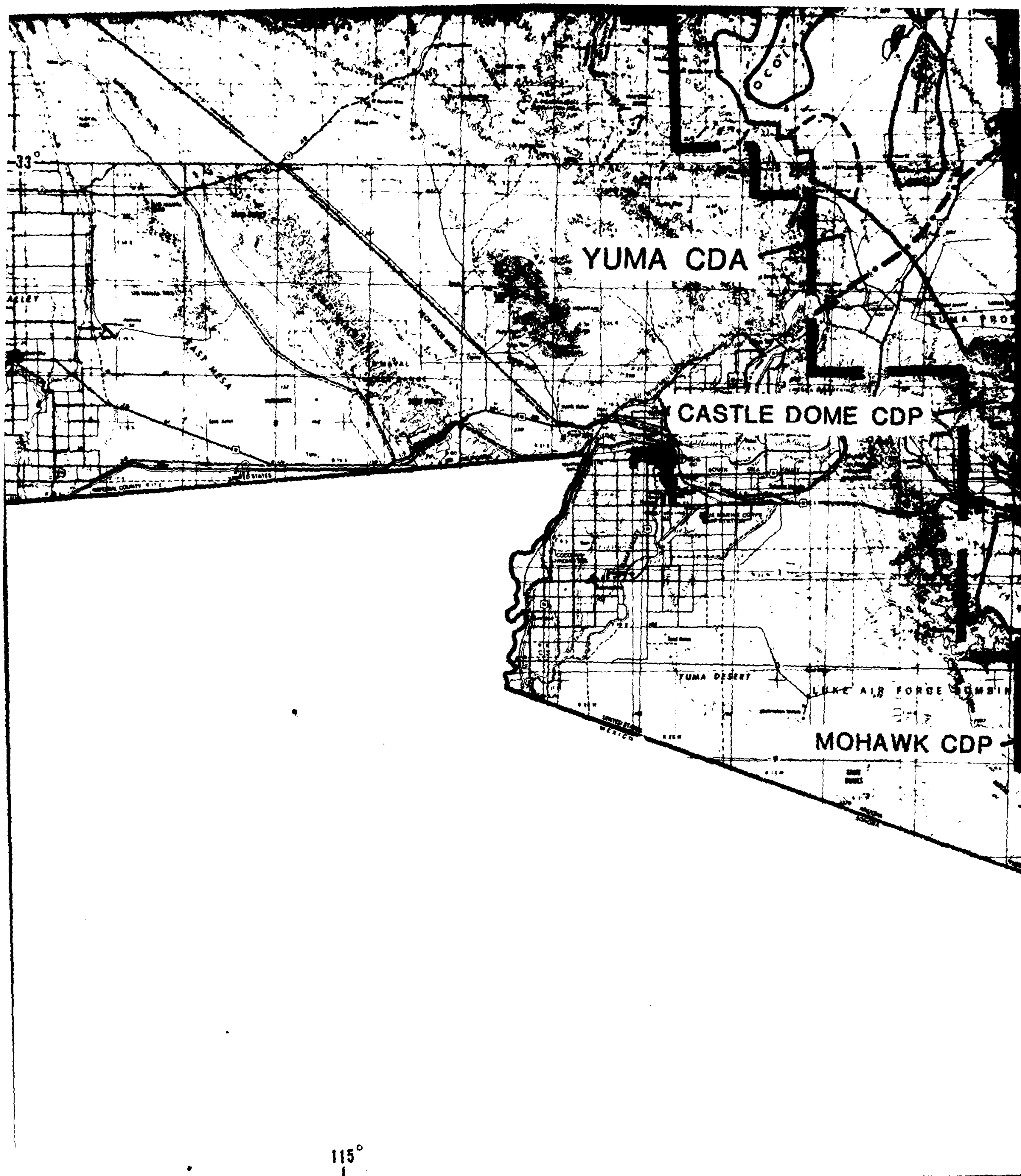
CACTUS CDP
PARKER CDA
LA POSA CDP
TRIGO CDP
CHOCOLATE MOUNTAIN AERIAL GUNNERY RANGE
(NAVAL)


McMULLEN CDP
RANEGRAS CDP
BOUSE CDA
KOFA GAME RANGE

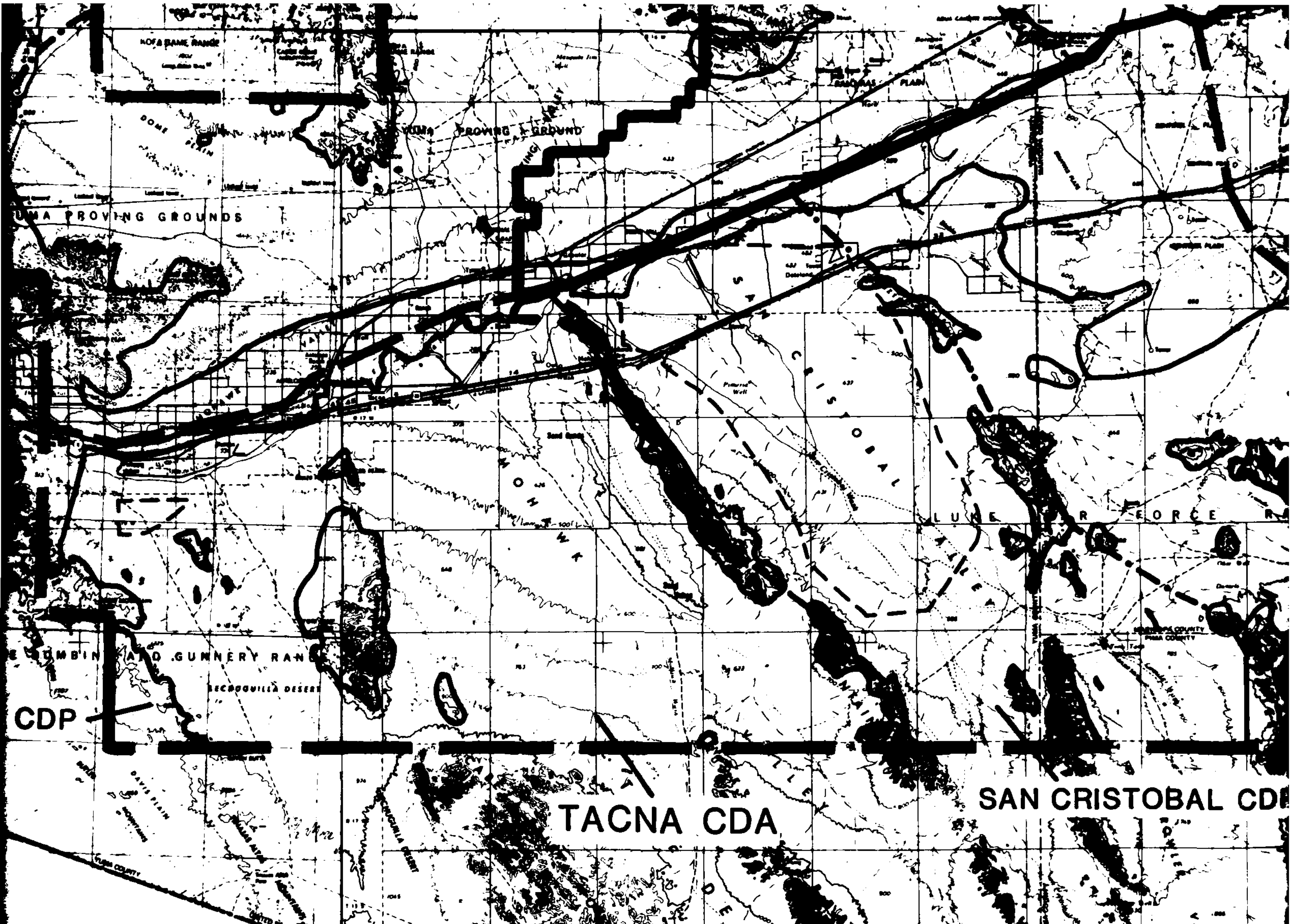
AGUILA CDP
McMULLEN CDP
HARQUAHALA CDP
TONOPAH DESERT


HASSAYAMPA CDP
WINTERSBURG CDA
PHOENIX
SCOTTSDALE
MESA
TEMPE
TONTO NATIONAL FOREST

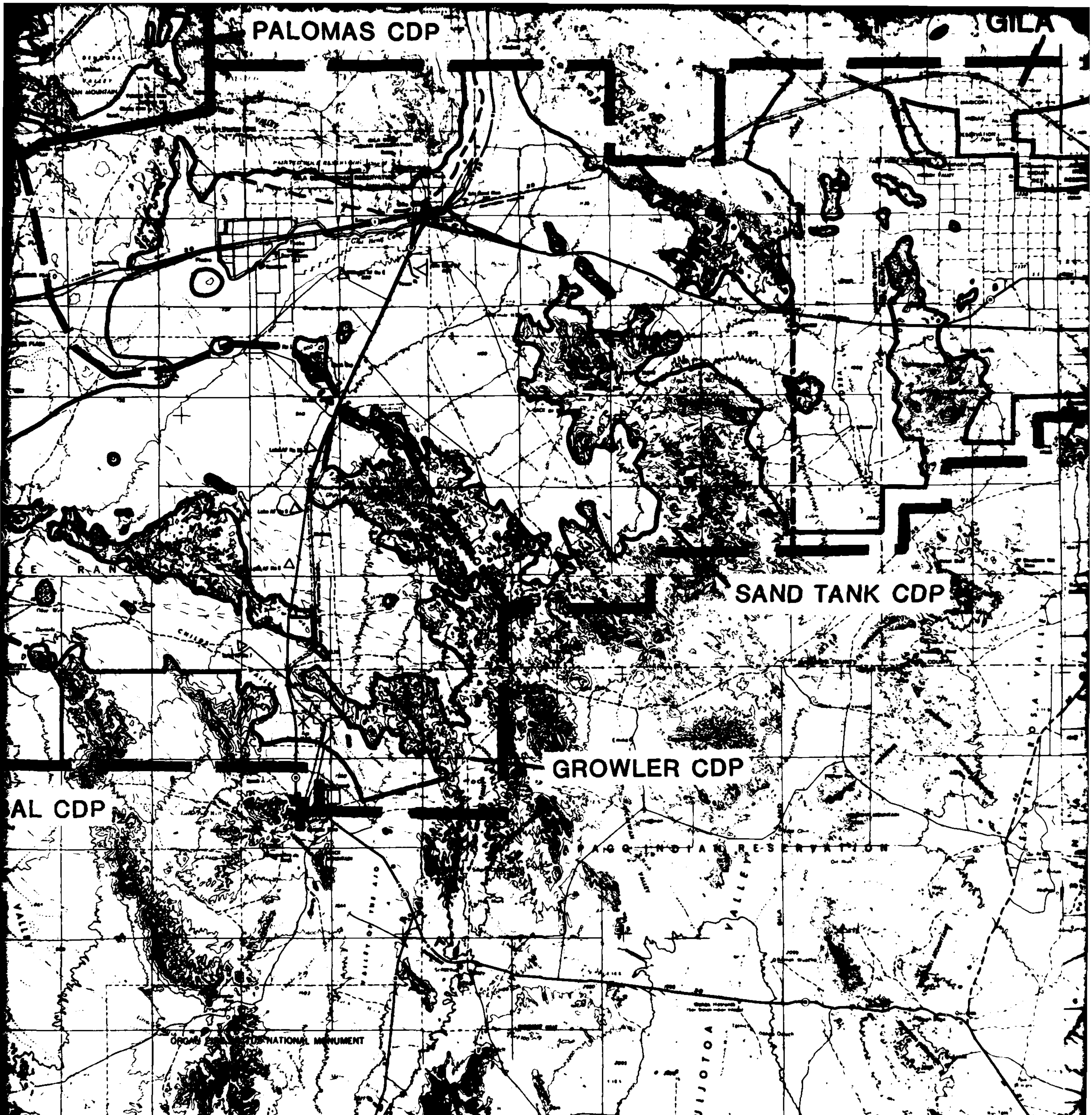

34°
Government Hill
TONTO NATIONAL FOREST
TONTO NATIONAL FOREST
TONTO NATIONAL FOREST
BASE LINE



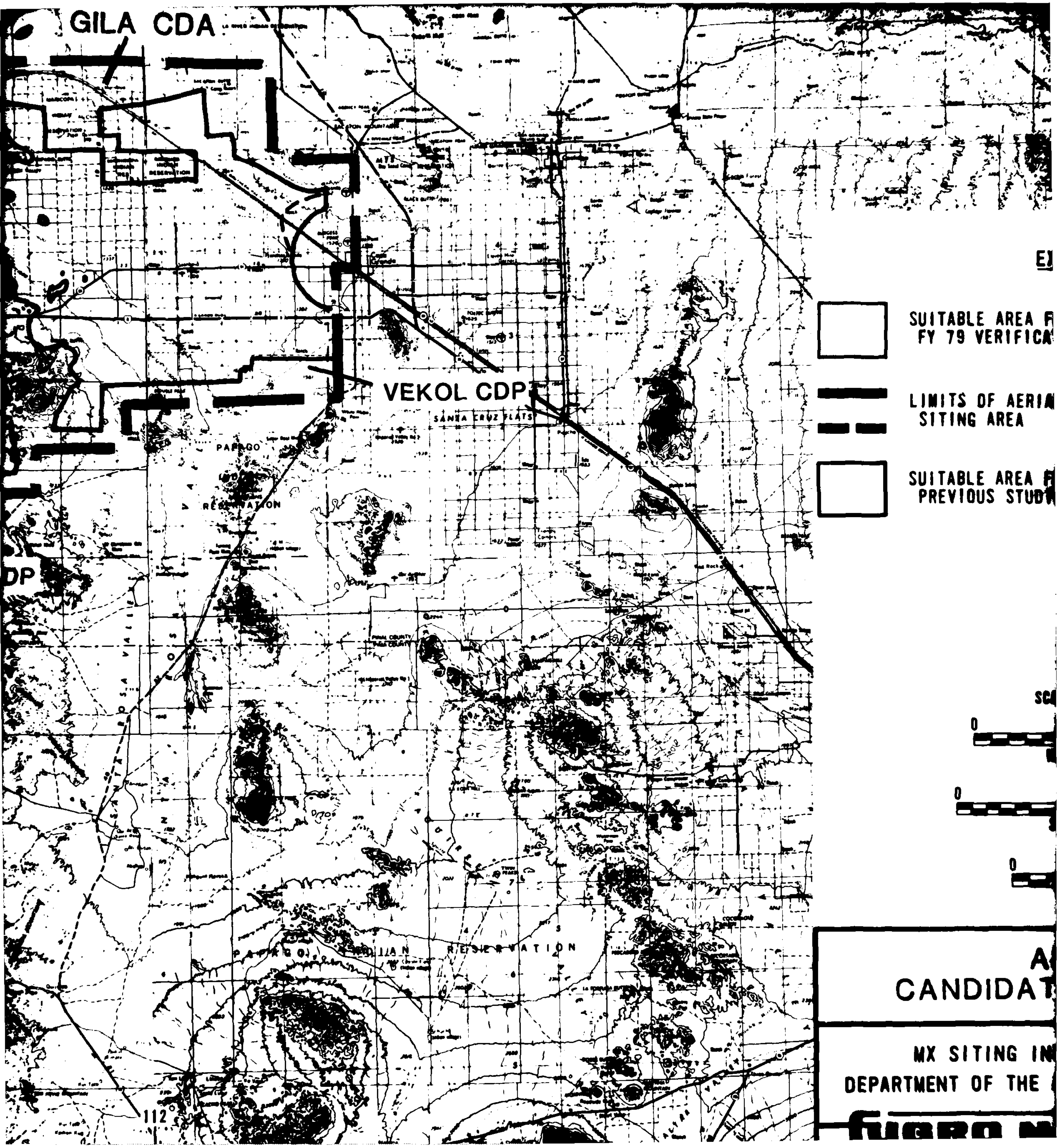
33°
YUMA CDA
CASTLE DOME CDP
MOHAWK CDP
YUMA DESERT
115°



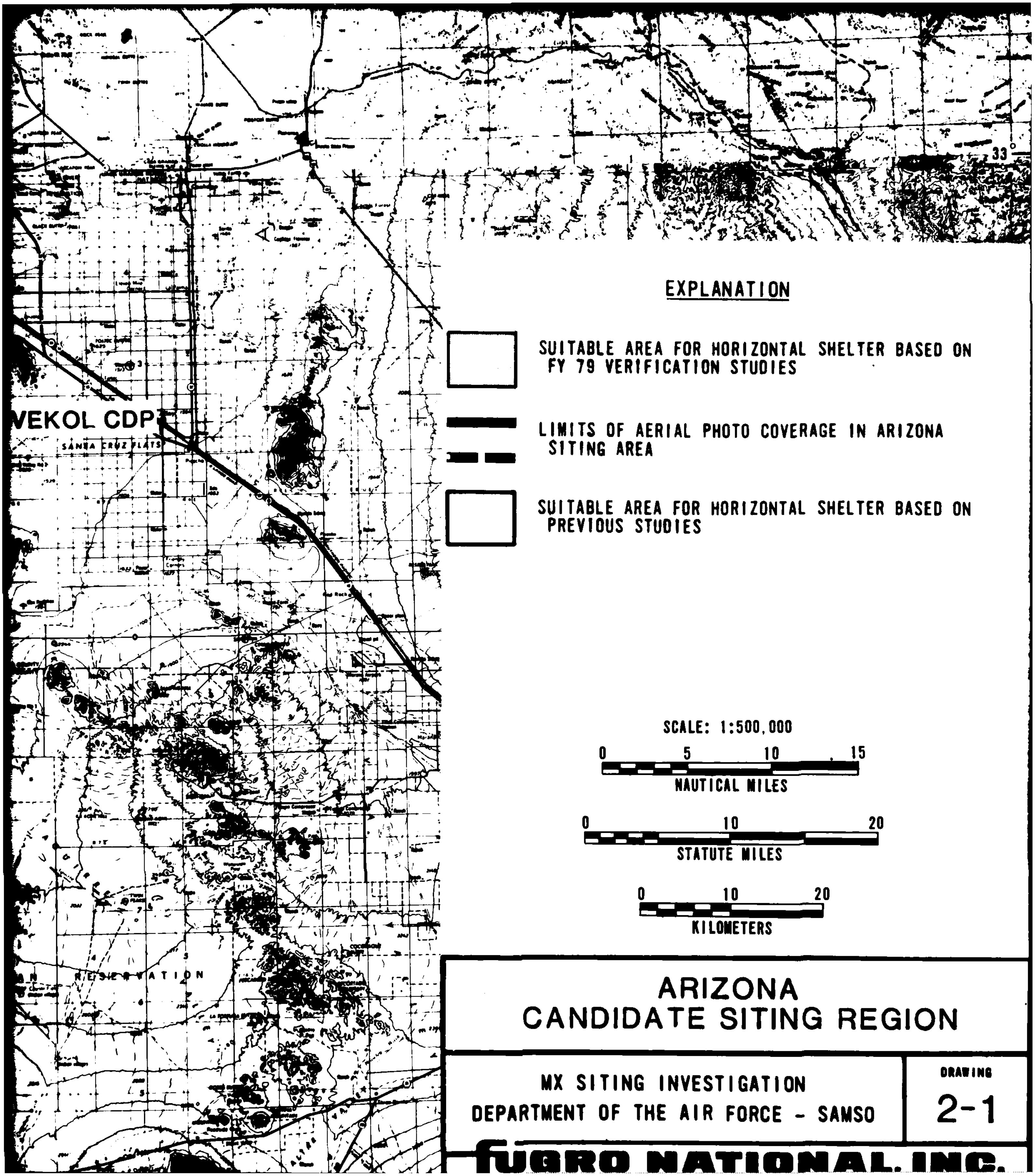
KOFA GAME RANGE
DOME PLAIN
YUMA PROVING GROUND
YUMA PROVING GROUNDS
SAN CRISTOBAL VALLEY
MOHAWK
LUKE AIR FORCE RANGE
COMBINED ARMS GUNNERY RANGE
LECHUGUILLA DESERT
CDP
TACNA CDA
SAN CRISTOBAL CD
CABEZA PRIETA GAME RANGE
VALLEY
DESERT
UNITED STATES
MEXICO
YUMA COUNTY
PIMA COUNTY
114°



PALOMAS CDP
GILA
SAND TANK CDP
GROWLER CDP
AL CDP
PAPAGO INDIAN RESERVATION
QUIJOTOA VALLEY
ORGAN PIPE CACTUS NATIONAL MONUMENT
113°
112



GILA CDA
VEKOL CDP
SANTA CRUZ FLATS
PAPAGO
RESERVATION
DP
PAPAGO INDIAN RESERVATION
112
SUITABLE AREA F
FY 79 VERIFICA
LIMITS OF AERIA
SITING AREA
SUITABLE AREA F
PREVIOUS STUD
A
CANDIDAT
MX SITING IN
DEPARTMENT OF THE



EXPLANATION

SUITABLE AREA FOR HORIZONTAL SHELTER BASED ON FY 79 VERIFICATION STUDIES

LIMITS OF AERIAL PHOTO COVERAGE IN ARIZONA SITING AREA

SUITABLE AREA FOR HORIZONTAL SHELTER BASED ON PREVIOUS STUDIES

SCALE: 1:500,000

0 5 10 15
NAUTICAL MILES

0 10 20
STATUTE MILES

0 10 20
KILOMETERS

ARIZONA
CANDIDATE SITING REGION

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING
2-1

FUGRO NATIONAL, INC.

3.0 LA POSA CDP

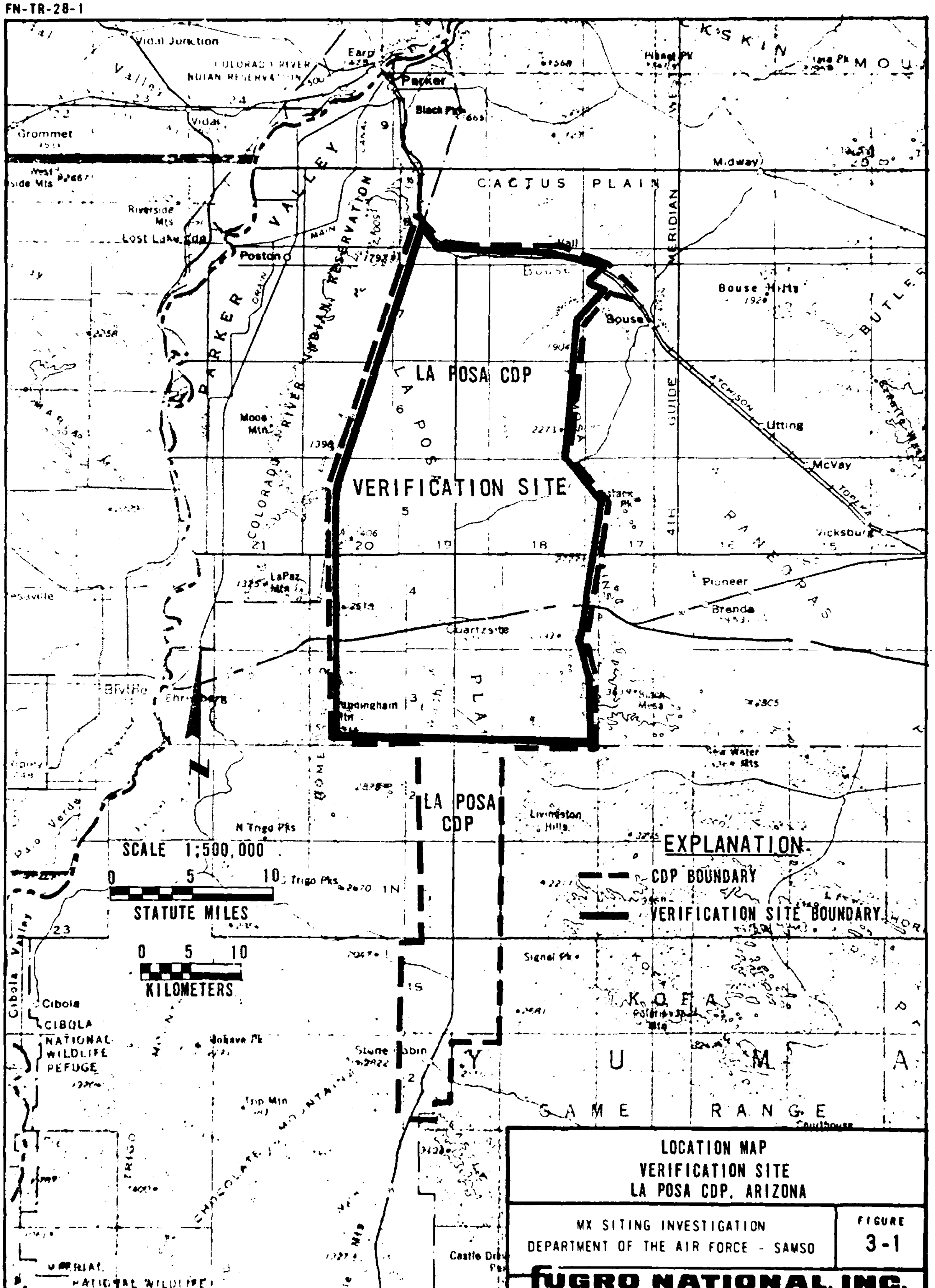
3.1 GEOGRAPHIC SETTING

The La Posa CDP is located in northern Yuma County, Arizona (Figure 3-1). It is bounded on the west by the Dome Rock Mountains and Colorado River Indian Reservation, on the east by the Plomosa Mountains, and on the south by the Chocolate and Castle Dome mountains. State Highway 72 forms the northern CDP boundary. The Verification site includes all of the CDP except the southern extension between the Kofa Game Range on the east and Yuma Proving Grounds on the west.

Access into and within the site is good. Interstate Highway 10 traverses the southern part, State Highway 72 traverses the northern part, and State Highway 95 runs north-south through the center of the site connecting Highways 10 and 72. An extensive network of unpaved roads, chiefly constructed for recreational purposes, allows access to all parts of the site. Quartzsite and Parker are the only significant population centers near the site. Quartzsite is in southern La Posa at the intersection of Highways 10 and 95. Parker is 12 miles (19 km) north of the site along Highway 95. The land within the site is undeveloped and is used for rangeland and recreation. Numerous small mining operations occur in the mountains surrounding the CDP.

3.2 SCOPE

The scope of geologic, geophysical, and soils engineering field activities performed in the site and laboratory tests performed



LOCATION MAP
VERIFICATION SITE
LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 3-1

FUGRO NATIONAL, INC.

10 AUG 79

on soil samples from the site are presented in Table 3-1. Locations of the geophysical and engineering activities are shown in Drawing 3-1 (end of Section 3.0).

3.3 GEOLOGIC SETTING

The northern Plomosa Mountains are composed of deformed Mesozoic sediments, generally metamorphosed to gneiss, overlain by Tertiary sandstone, shale, limestone, and conglomerate (Jemmett, 1966; Wilson, et al., 1969). Precambrian, Paleozoic, and Mesozoic metamorphic rocks are located in the southern Plomosa Mountains (Jemmett, 1966; Wilson, et al., 1969). Tertiary andesite dikes, plugs, and flows are present throughout the Plomosa Mountains, and Quaternary basalt caps mesas in the southern part of the range. The Dome Rock Mountains, to the west, consist of a similar assemblage of Mesozoic metasedimentary and metamorphic rocks intruded by Mesozoic granite and quartz diorite.

Structure in rock areas is extremely complex, with extensive folding and faulting. However, no faults are traceable into basin-fill sediments. Embayed mountain fronts and pediments (Jemmett, 1966), along with the lack of faulting in basin-fill deposits, indicate a lack of recent tectonic activity.

Basin-fill stratigraphy and distribution of surficial geologic units in La Posa Plain have been greatly influenced by its proximity to the Colorado River. Colorado River terrace deposits are present in the subsurface under much of La Posa Plain, but

GEOLOGY AND GEOPHYSICS

TYPE OF ACTIVITY	NUMBER OF ACTIVITIES
Geologic mapping stations	87
Shallow refraction	19
Electrical resistivity	19
Gravity profiles	3

ENGINEERING-LABORATORY TESTS

TYPE OF TEST	NUMBER OF TESTS
Moisture/density	108
Specific gravity	4
Sieve analysis	77
Hydrometer	2
Atterberg limits	10
Consolidation	0
Unconfined compression	1
Triaxial compression	2
Direct shear	6
Compaction	7
CBR	7
Chemical analysis	12

ENGINEERING

NUMBER OF BORINGS	NOMINAL DEPTH FEET (METERS)
6	160 (49)
NUMBER OF TRENCHES	**NOMINAL DEPTH FEET (METERS)**
3	14 (4)
2	8 (2)
NUMBER OF TEST PITS	**NOMINAL DEPTH FEET (METERS)**
28	5 (2)
NUMBER OF CPTs	**RANGE OF DEPTH FEET (METERS)**
67	2-35 (1-11)
TYPE OF ACTIVITY	**NUMBER OF ACTIVITIES**
Surficial soil samples	33
Field CBR tests	0

SCOPE OF ACTIVITIES
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 3-1

FUGRO NATIONAL, INC.

occur at the surface only along the western edge (Fugro, 1975). These deposits at the surface are composed of rounded gravels and gravelly sands. Intermediate age alluvial fan deposits are the predominant surficial geologic unit, encompassing approximately 25 percent of the site. These deposits are heavily pavemented and patinated and moderately cemented.

Stabilized eolian dune and sheet sands mantle alluvial deposits in northern La Posa, with the source of the sand being ancestral flood plains of the Colorado River. Downcutting of the Colorado River during the Quaternary Period has resulted in entrenchment of streams and formation of terraces. Nearly all modern alluvial material is carried in these entrenched streams into the Colorado River, and younger alluvial fan deposits are rare.

3.4 SURFACE SOILS

Surficial soils of the La Posa Site are predominantly coarse-grained (granular). Soils from predominant surficial geologic units (Drawing 3-2) have been grouped into the following four categories based on their physical and engineering characteristics:

1. Uniform sands (from geologic units A3s and A3d).
2. Sands and silty sands (from geologic units Als, A2s, A5ys, and A5is).
3. Sandy gravels and gravelly sands (from geologic units Als, Alg, A2s, A5is, and A5ig).
4. Silts and clays (geologic unit A5is).

3.4.1 Characteristics

Based on laboratory and field test results, the characteristics of surficial soils were evaluated and are summarized in Table 3-2. In addition to the physical characteristics, road design data consisting of laboratory compaction and California Bearing Ratio (CBR) test results, average depth and depth range of low-strength surficial soils, and suitability of the soils for road construction use are included in the table. The range of gradation for the four categories of surficial soils is presented in Figure 3-2.

Uniform (poorly graded) fine to medium sands have an approximate areal distribution of 20 to 30 percent of the site These soils occur as eolian (A3) deposits which cover most of the northern third of the site and interfinger with intermediate alluvial fan and active stream channel deposits in the central third. Eolian sands typically contain traces to little nonplastic silt and are usually uncemented in the surficial zone.

Coarse to fine sands and silty sands cover approximately 10 to 20 percent of the site. These soils are widely distributed, occurring randomly in young and intermediate fans (A5ys and A5is), in terrace remnants (A2s) along the western margin of the site north of Tyson Wash, and in active stream channels (A1s). Sands are usually poorly graded, contain traces to some fines, and frequently contain gravel traces. These soils are normally nonplastic but occasionally slightly plastic. Sands of intermediate fans are frequently cemented (calcium carbonate)

SOIL DESCRIPTION		Uniform fine to medium sands		Sands and
USCS SYMBOLS		SP, SM		SM
PREDOMINANT SURFICIAL GEOLOGIC UNITS		A3s and A3d		A1s, A2s, A5
ESTIMATED AREAL EXTENT %		20-30		10-20
PHYSICAL PROPERTIES				
COBBLES 3 - 12 inches (8 - 30 cm) %		0		0-5
GRAVEL %		0-11	[8]	14-20
SAND %		69-98	[8]	49-55
SILT AND CLAY %		2-28	[8]	31-32
LIQUID LIMIT		NDA		19
PLASTICITY INDEX		NDA		4
ROAD DESIGN DATA				
MAXIMUM DRY DENSITY pcf (kg/m3)		117.5-120.9 (1882-1936)	[2]	133.0 (2130)
OPTIMUM MOISTURE CONTENT %		8.2-9.0	[2]	8.0
CBR AT 90% RELATIVE COMPACTION %		7-12	[2]	9
SUITABILITY AS ROAD SUBGRADE (1)		poor to fair		fair to goo
SUITABILITY AS ROAD SUBBASE OR BASE (1)		poor		poor to fai
THICKNESS OF LOW STRENGTH SURFICIAL SOIL (2)	RANGE ft (m)	2.1-10.9 (0.6-3.3)	[20]	1.1-6.4 (0.3-2.0)
	AVERAGE ft (m)	4.3 (1.3)	[20]	2.7 (0.8)

(1) Suitability is a subjective rating explained in Section A5.0 of the Appendix.

(2) Low strength surficial soil is defined as soil which will perform poorly as a road subgrade at its present consistency; see Table 3-3 for details.

NOTES:
- [ ]
- NDA

Sands and Silty Sands		Sandy Gravels and Gravelly Sands		Sandy Silts and Sandy Clays	
SM		GW, GP, GM, GC, SP, and SM		ML, CL	
A1s, A2s, A5ys and A5is		A1s, A1g, A2s, A5is, and A5ig		A5is	
10-20		45-55		0-10	
0-5		0-10		0	
14-20	[3]	26-63	[14]	1-15	[2]
49-55	[3]	25-57	[14]	30-42	[2]
31-32	[3]	1-31	[14]	55-57	[2]
19	[1]	24-33	[5]	21-33	[2]
4	[1]	3-11	[5]	7-11	[2]
133.0 (2130)	[1]	122.5-131.0 (1962-2098)	[4]	NDA	
8.0	[1]	8.0-12.5	[4]	NDA	
9	[1]	10-35	[4]	NDA	
fair to good		good to very good		poor	
poor to fair		fair to good		not suitable	
1.1-6.4 (0.3-2.0)	[9]	0.3-4.0 (0.1-1.2)	[31]	0.3-1.7 (0.1-0.5)	[7]
2.7 (0.8)	[9]	1.3 (0.4)	[31]	1.2 (0.4)	[7]

NOTES:

- [ ] – Number of tests performed
- NDA – No data available (insufficient data or tests not performed)

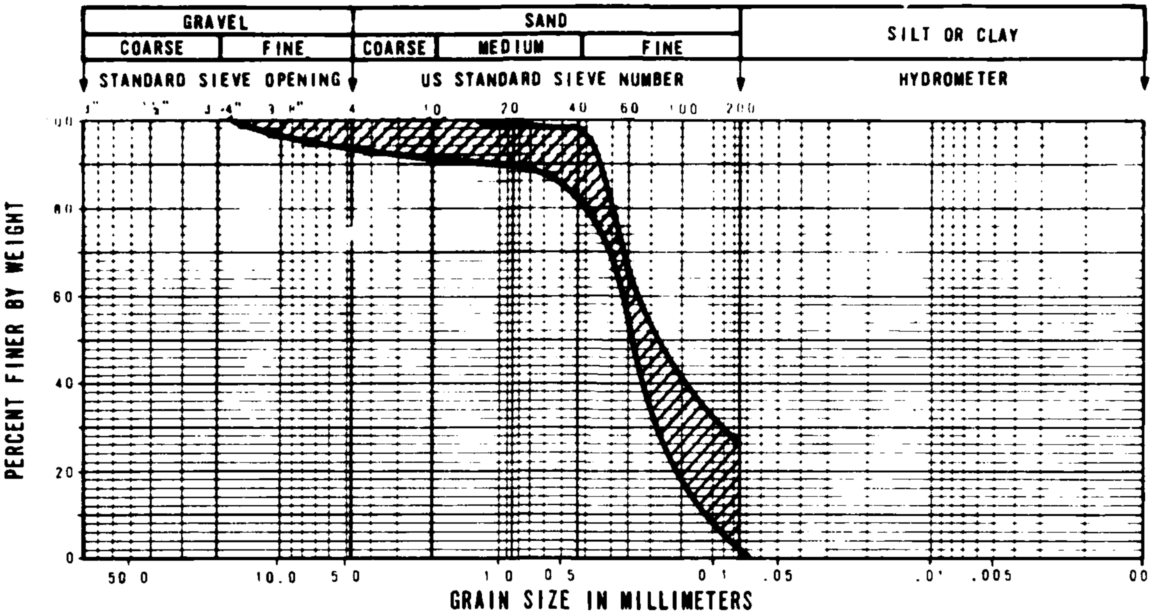
CHARACTERISTICS OF SURFICIAL SOILS VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE – SAMSO

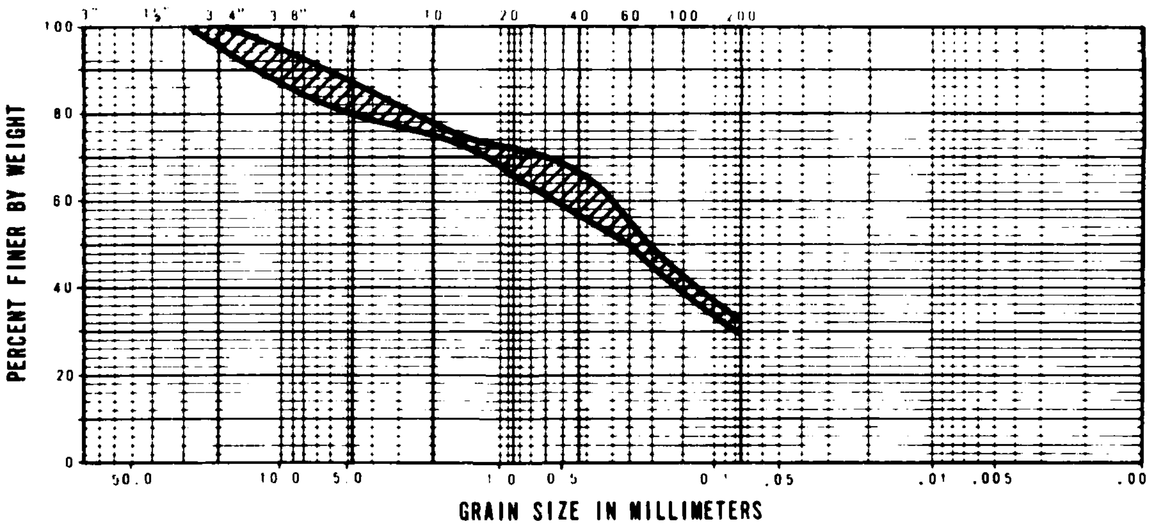
TABLE 3-2

FUGRO NATIONAL, INC.

AFV-19



SOIL DESCRIPTION: Uniform fine to medium sands from 0 to 2 feet (0.0 tO 0.6m)



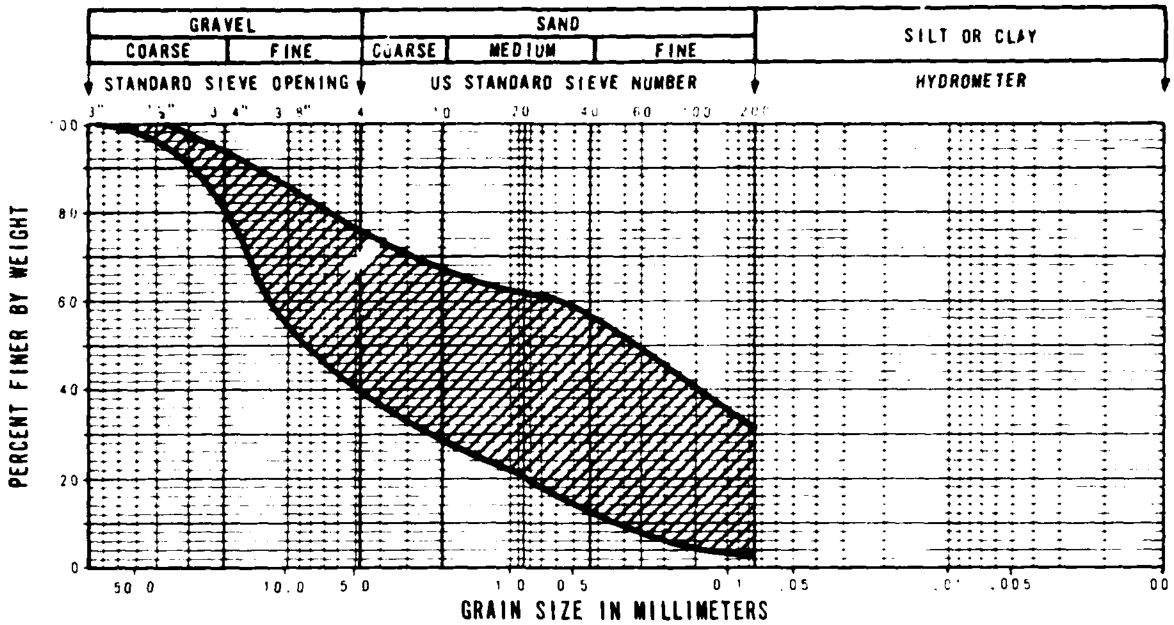
SOIL DESCRIPTION: Sands and silty sands from 0 to 2 feet (0.0 to 0.6m)

RANGE OF GRADATION OF SURFICIAL SOILS
VERIFICATION SITE, LA POSA CDP, ARIZONA

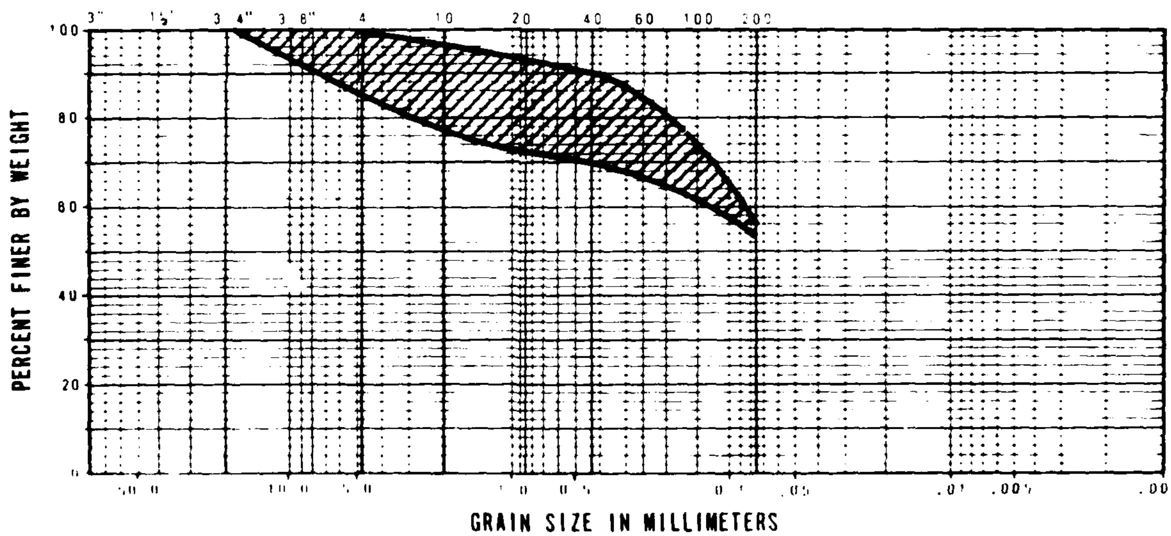
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 3-2
1 OF 2

FUGRO NATIONAL, INC.



SOIL DESCRIPTION: Sandy gravels and gravelly sands from 0 to 2 feet (0 0 to 0 6m)



SOIL DESCRIPTION: Sandy silts and sandy clays from 0 to 2 feet (0.0 to 0 6m)

RANGE OF GRADATION OF SURFICIAL SOILS
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 3-2
2 OF 2

FUGRO NATIONAL, INC.

below 1 foot (0.3 m), but sands of other units are typically uncemented in the surficial zone.

Sandy gravels and g.avelly sands constitute the predominant surficial soil type with an approximate areal distribution ranging from 45 to 55 percent of the site. The major concentrations of gravelly soils are intermediate fans (A5is and A5ig) in the central and southern portions of the site. Gravelly soils are also randomly distributed in drainages throughout the entire site and in the terrace remnants along the western site margin. These soils have a wide particle size distribution, are mostly poorly graded, contain traces to appreciable fines, and are usually nonplastic. Calcium carbonate cementation is moderately to well developed below depths of 1 foot (0.3 m) in many intermediate fan deposits.

Silts and clays are the least common surficial soil type. These fine-grained soils cover less than ten percent of the site and occur as isolated pockets in intermediate alluvial fans. Fine-grained soils exhibit slight to medium plasticity, contain appreciable amounts of sand, and gravel traces in some locations. Moderate to strong calcium carbonate cementation is usually encountered at depths from 0.5 to 2 feet (0.2 to 0.6 m).

3.4.2 Low-Strength Surficial Soil

Cone Penetrometer Test (CPT) results were used in conjunction with soil classifications to evaluate in situ surficial soils.

The thickness of low-strength surficial soil at each CPT location was estimated and is tabulated in Table 3-3. The range and mean thickness of the low-strength interval are summarized in Table 3-2 for the four surficial soil types. Uniform eolian sands exhibit low strength to depths ranging from 2.0 to 10.9 feet (0.6 to 3.3 m) with an average of 4.3 feet (1.3 m). Coarser sands and gravelly soils of other geologic units (Columns 2 and 3 of Table 3-2) exhibit low strength to depths ranging from 0.3 to 6.4 feet (0.1 to 2.0 m) with an average of 1.6 feet (0.5 m). Silts and clays exhibit low strength to depths ranging from 0.3 to 1.7 feet (0.1 to 0.5 m) with an average of 1.2 feet (0.4 m). Variations in the extent of low strength, granular, surficial soils are related to differences in gravel content, method of deposition, and degree of calcium carbonate cementation. The eolian soils generally exhibit lower cone resistance values than alluvial/fluvial deposits due to the absence of gravel, lower relative density, and general absence of cementation. Cone resistance values for fine-grained soils are influenced by temporary strengths due to desiccation and calcium carbonate cementation at shallow depths.

3.5 SUBSURFACE SOILS

Soil profiles, Figures 3-3 through 3-6, show the composition of subsurface soils with depth, as determined from borings, trenches, and test pits. Subsurface soils are predominantly coarse-grained (granular) consisting of sandy gravels, gravelly sand, and silty sand. Fine-grained soils (silts and clays) occur as localized pockets or interbeds. Fine to medium sands

CONE PENETROMETER TEST NUMBER[1]	THICKNESS OF LOW STRENGTH SURFICIAL SOIL[2]		SOIL TYPE[3]
	FEET	METERS	
C-1	10.9	3.3	SM
C-2	7.0	2 1	SP-SM
C-3	4.6	1.4	SP-SM
C-4	4.3	1.3	SP-SM
C-5	4.6	1.4	SP
C-6	3.4	1 0	SM
C-7	2.7	0 8	GP
C-8	3.6	1 1	SM
C-9	1.1	0 3	SM/SP
C-10	3.7	1.1	SM
C-11	0.9	0.3	GP-GM
C-12	0.3	0.1	GM
C-13	4.5	1.4	SM
C-14	3.1	0.9	SC-SM
C-15	3.5	1.1	SM
C-16	3.0	0.9	SM
C-17	2.3	0.7	SM, GP-GM
C-18	0.8	0.2	GM
C-19	3.2	0 9	SM
C-20	2.2	0.7	SM
C-21	3.3	1.0	SM
C-22	4.2	1.3	SM
C-23	4.5	1 4	SM
C-24	4.7	1 4	SM
C-25	4.5	1.4	SM
C-26	3.3	1 0	SM
C-27	2.1	0 6	SM/GM
C-28	3.0	0 9	SM

CONE PENETROMETER TEST NUMBER[1]	THICKNESS OF L[illegible] SURFICIAL [illegible]
	FEET
C-29	5.5
C-30	6.4
C-31	1.8
C-32	1.5
C-33	1.3
C-34	0.9
C-35	0.5
C-36	1.0
C-37	1.3
C-38	0.5
C-39	0.3
C-40	0.9
C-41	4.0
C-42	3.9
C-43	1.7
C-44	1.5
C-45	1.7
C-46	1.8
C-47	1.0
C-48	1.0
C-49	1.0
C-50	3.5
C-51	2.9
C-52	1.0
C-53	0.4
C-54	0.4
C-55	0.6
C-56	0.4

(1) For Cone Penetrometer Test locations see Drawing Activity Location Map.

(2) Thickness corresponds to depth below ground surface. Low strength surficial soil is defined as soil which will perform poorly as a road subgrade at its present consistency. Low strength is based on Cone Penetrometer Test results using the following criteria:

Coarse grained soils: $q_c < 120$ tsf (117 kg/cm^2)
Fine grained soils: $q_c < 80$ tsf (78 kg/cm^2)

where q_c is cone resistance.

(3) Soil type is based on Unified Soil Classification System; see Section A5.0 in the Appendix for explanation

NOTES: • For
str
of

• SM/

• NDA

THICKNESS OF LOW STRENGTH SURFICIAL SOIL.(2) FEET	METERS	SOIL TYPE (3)
5.5	1.7	SP-SM
6.4	2.0	SM
1.8	0.5	SM GP
1.5	0.5	GP-GM
1.3	0.4	SM GP-GM
0.9	0.3	SM GP-GM
0.5	0.2	GM
1.0	0.3	GM
1.3	0.4	GC
0.5	0.2	CL
0.3	0.1	ML
0.9	0.3	CL
4.0	1.2	GM-GC GC
3.9	1.2	SP
1.7	0.5	CL-ML
1.5	0.5	ML
1.7	0.5	ML
1.8	0.5	SP-SM/GP-GM
1.0	0.3	SM
1.0	0.3	SP
1.0	0.3	GP
3.5	1.1	GP-GM
2.9	0.9	SM
1.0	0.3	GM
0.4	0.1	GW-GM
0.4	0.1	GP
0.6	0.2	GM
0.4	0.1	GP-GM

CONE PENETROMETER TEST NUMBER(1)	THICKNESS OF LOW STRENGTH SURFICIAL SOIL.(2) FEET	METERS	SOIL TYPE (3)
C-57	1.0	0.3	GM GP-GM
C-58	1.0	0.3	GM
C-59	0.8	0.2	SM GP-GM
C-60	1.2	0.4	SM
C-61	1.1	0.3	SM
C-62	1.7	0.5	SM
C-63	1.5	0.5	ML
C-64	0.9	0.3	GM
C-65	0.7	0.2	SP
C-66	0.8	0.2	GP
C-67	2.0	0.6	SM

NOTES:
- For fine grained soils (ML, CL, MH and CH), thickness of low strength surficial soil will vary depending on moisture content of the soil at time of testing.
- SM/GM - indicates SM underlain by GM
- NDA - No data available

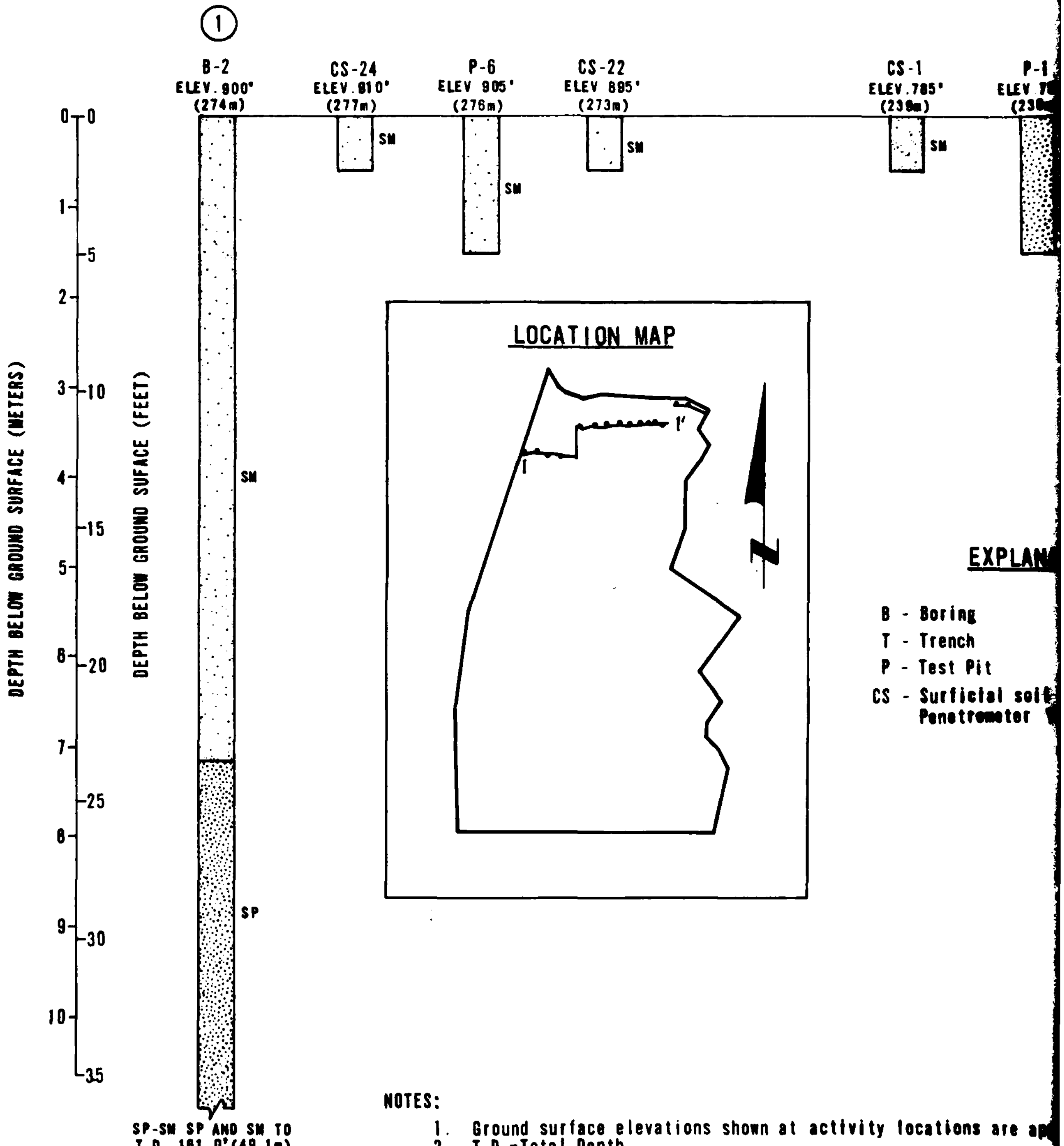
THICKNESS OF LOW STRENGTH SURFICIAL SOILS
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 3-3

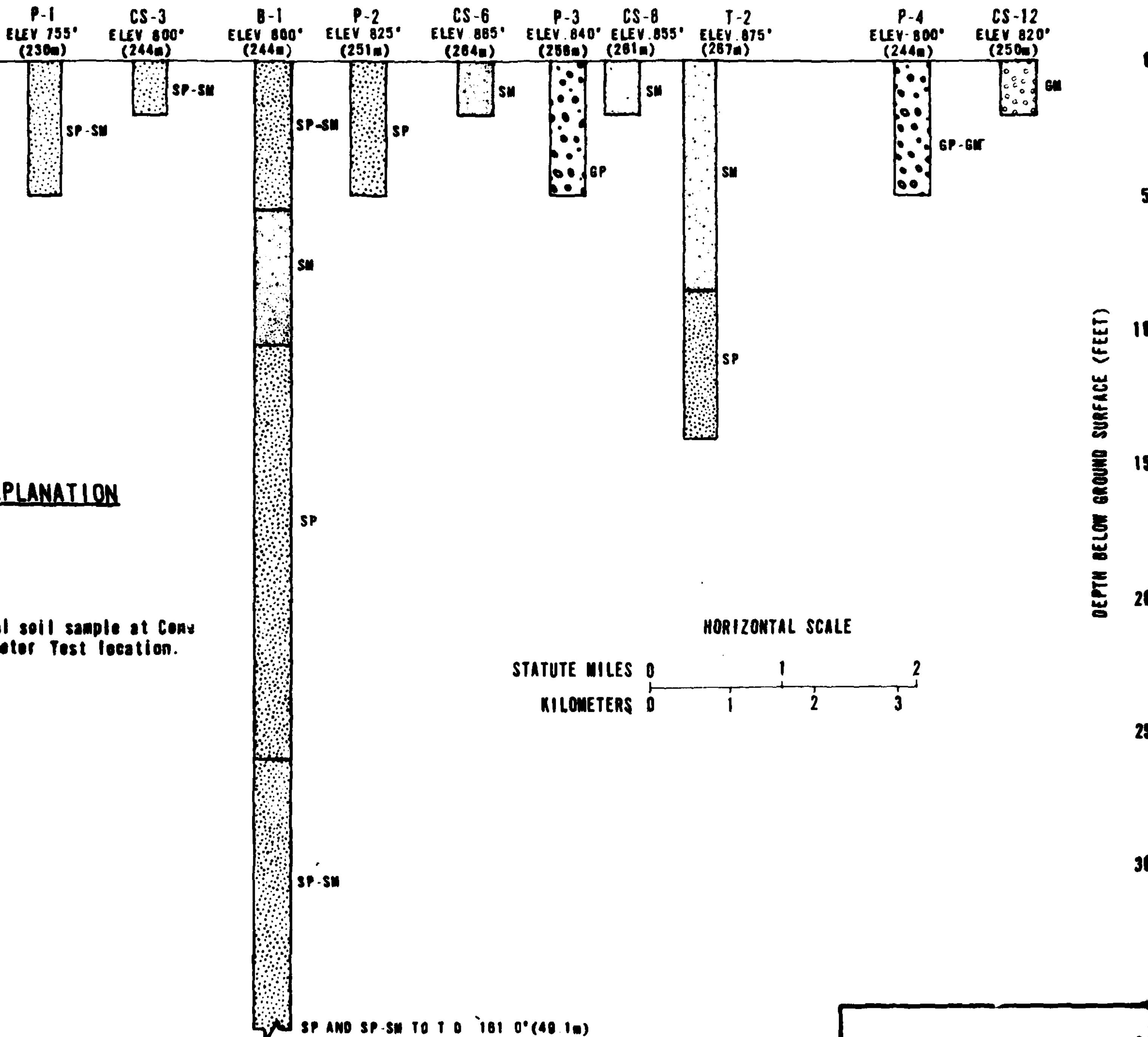
FUGRO NATIONAL, INC.

AFV-21



NOTES:

1. Ground surface elevations shown at activity locations are ap
2. T.D.=Total Depth.
3. Soil types shown adjacent to soil column are based on Unifie
Classification System (USCS) and are explained in the appen



EXPLANATION

...ing
...nch
...t Pit
...ficial soil sample at Cone
...etrometer Test location.

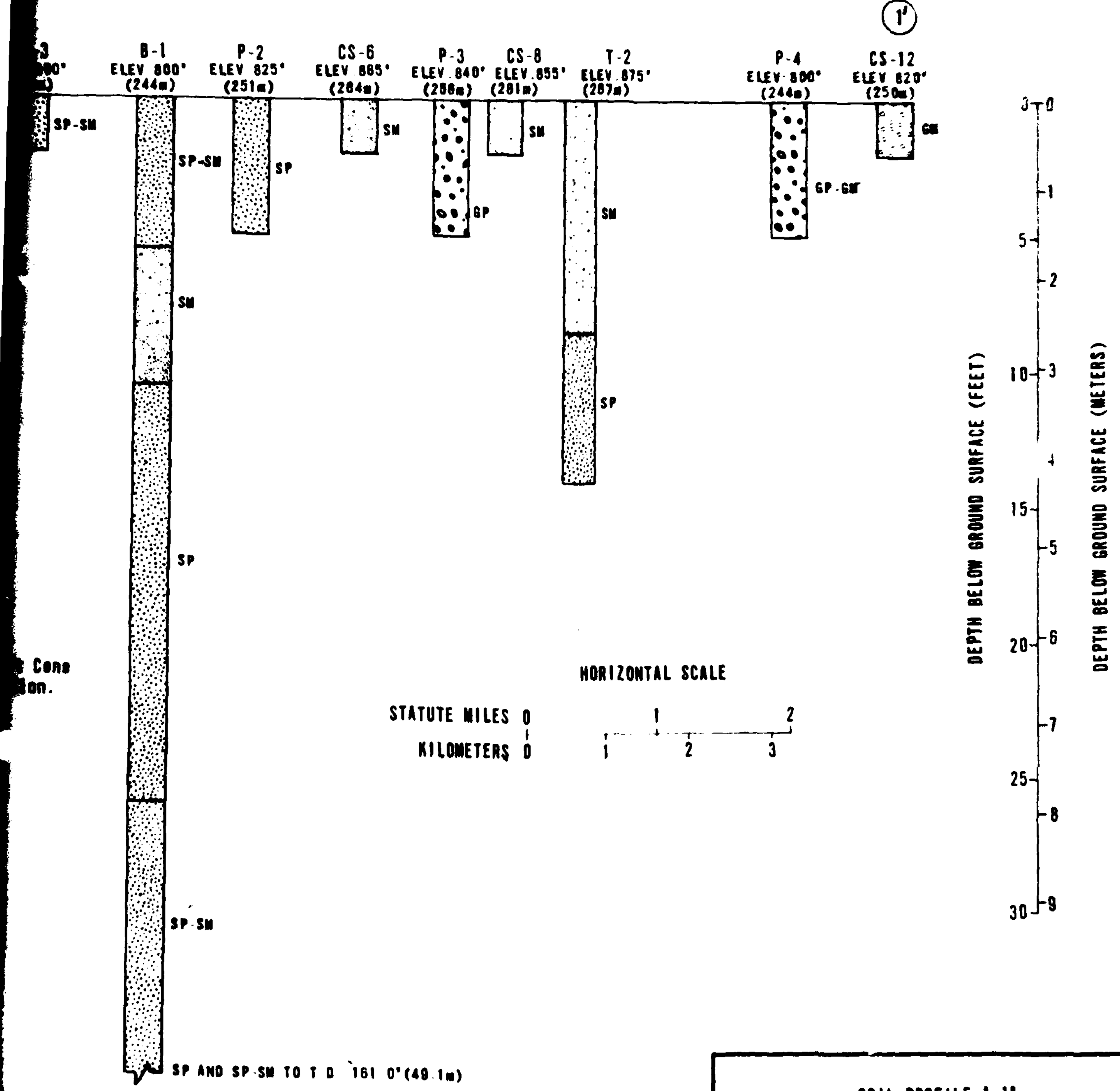
...ons are approximate.

... on Unified Soil.
... the appendix.

SOIL PROFILE 1-1'
VERIFICATION SITE, LA POSA ...

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - S...

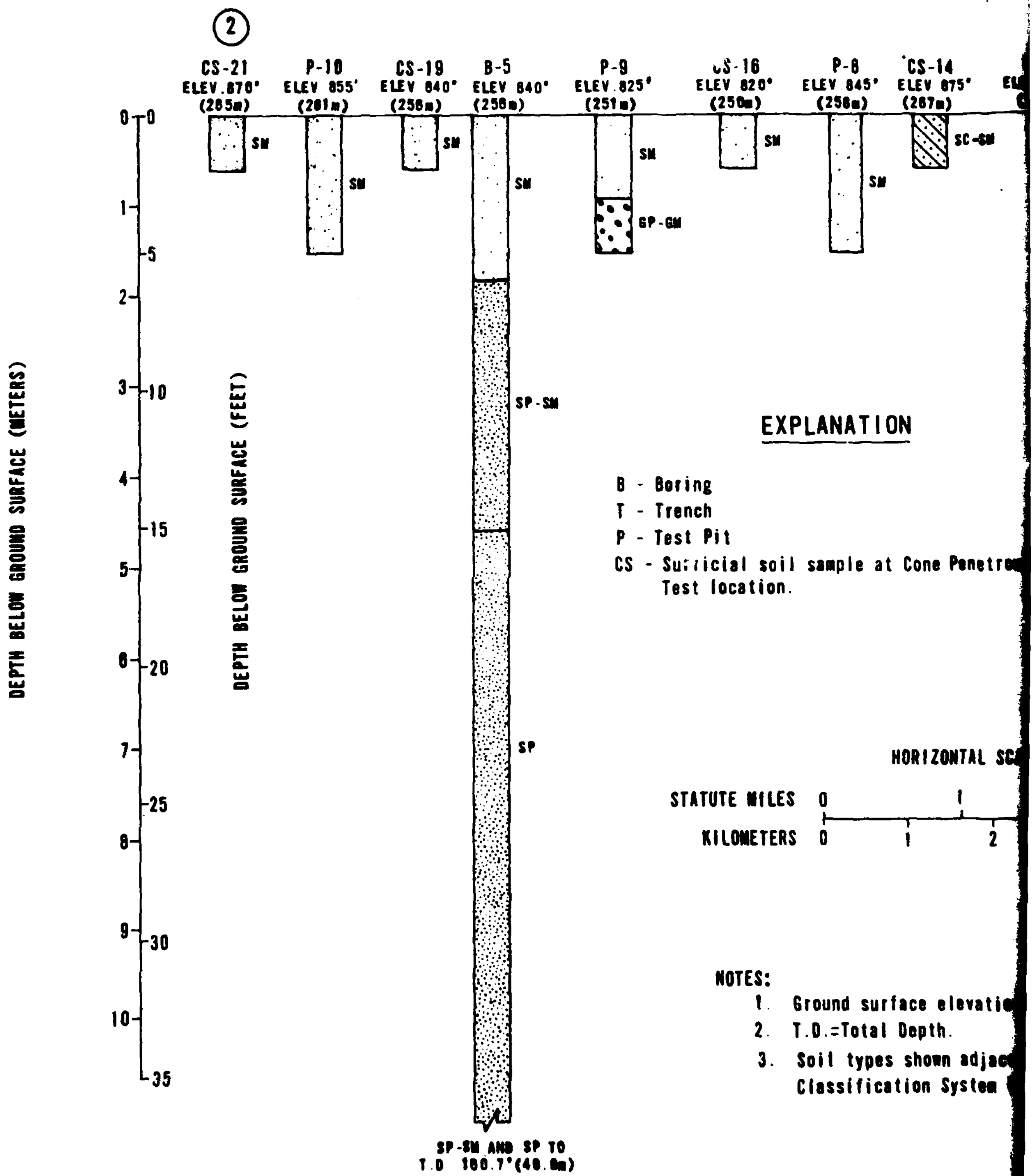
FUGRO NATION...



SOIL PROFILE 1-1'
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	FIGURE 3-3

FUGRO NATIONAL, INC.



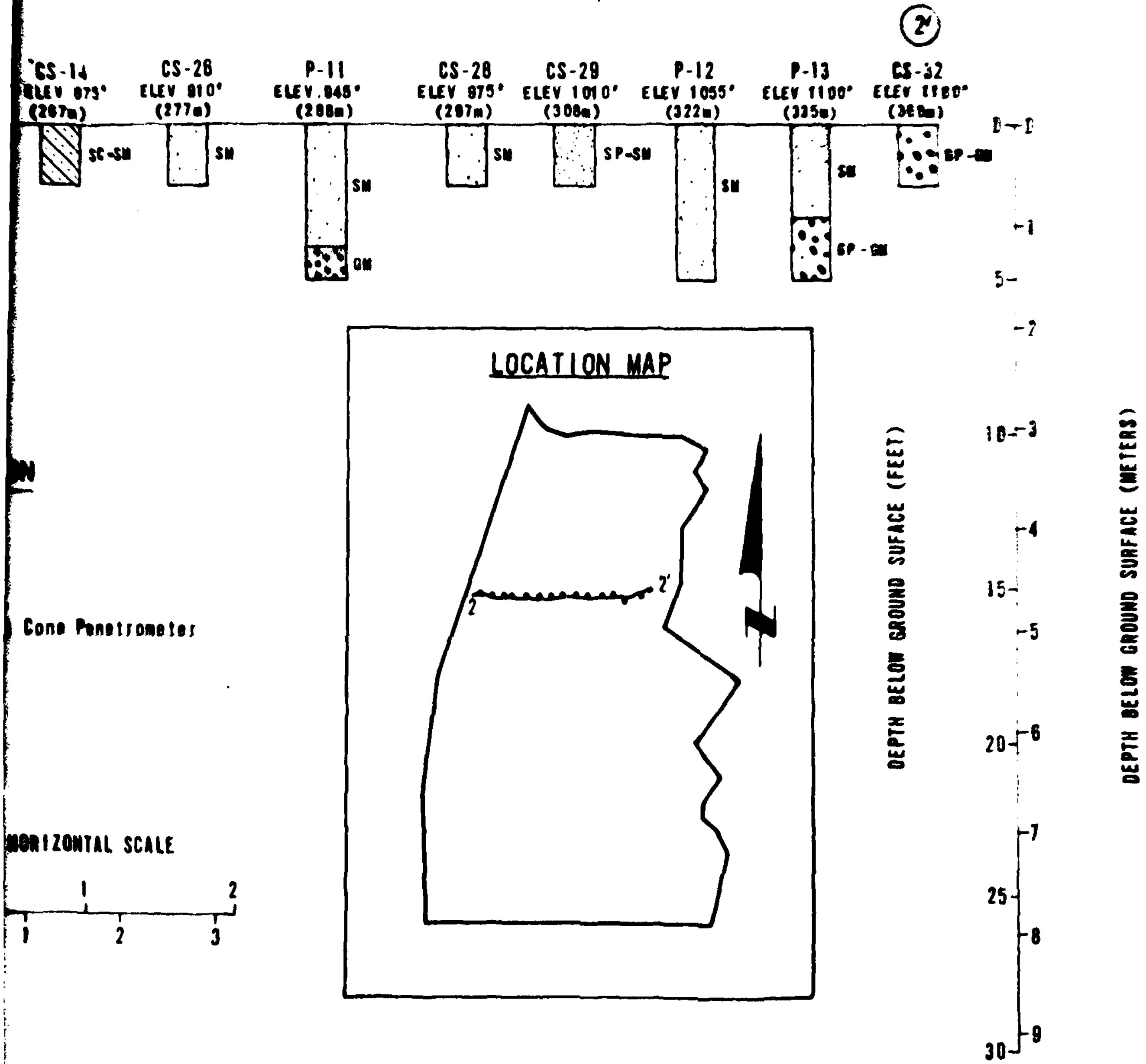
EXPLANATION

B - Boring
T - Trench
P - Test Pit
CS - Surficial soil sample at Cone Penetro
Test location.

HORIZONTAL SC

STATUTE MILES	0		1	
KILOMETERS	0	1		2

NOTES:
1. Ground surface elevati
2. T.D.=Total Depth.
3. Soil types shown adjac
Classification System

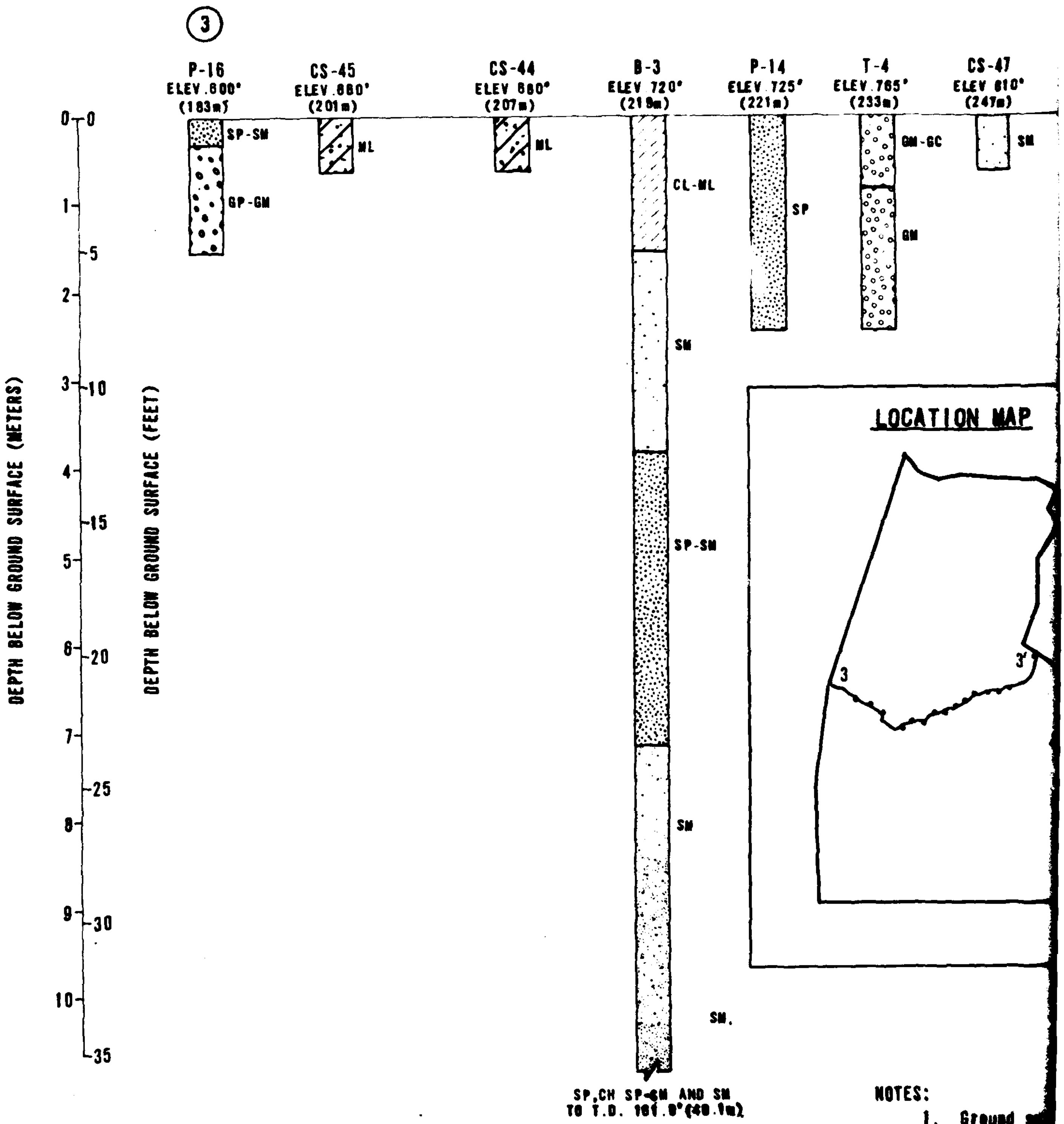


ace elevations shown at activity locations are approximate.
Depth
shown adjacent to soil column are based on Unified Soil
tion System (USCS) and are explained in the appendix.

SOIL PROFILE 2-2'
VERIFICATION SITE, LA POSA CDP, ARIZONA

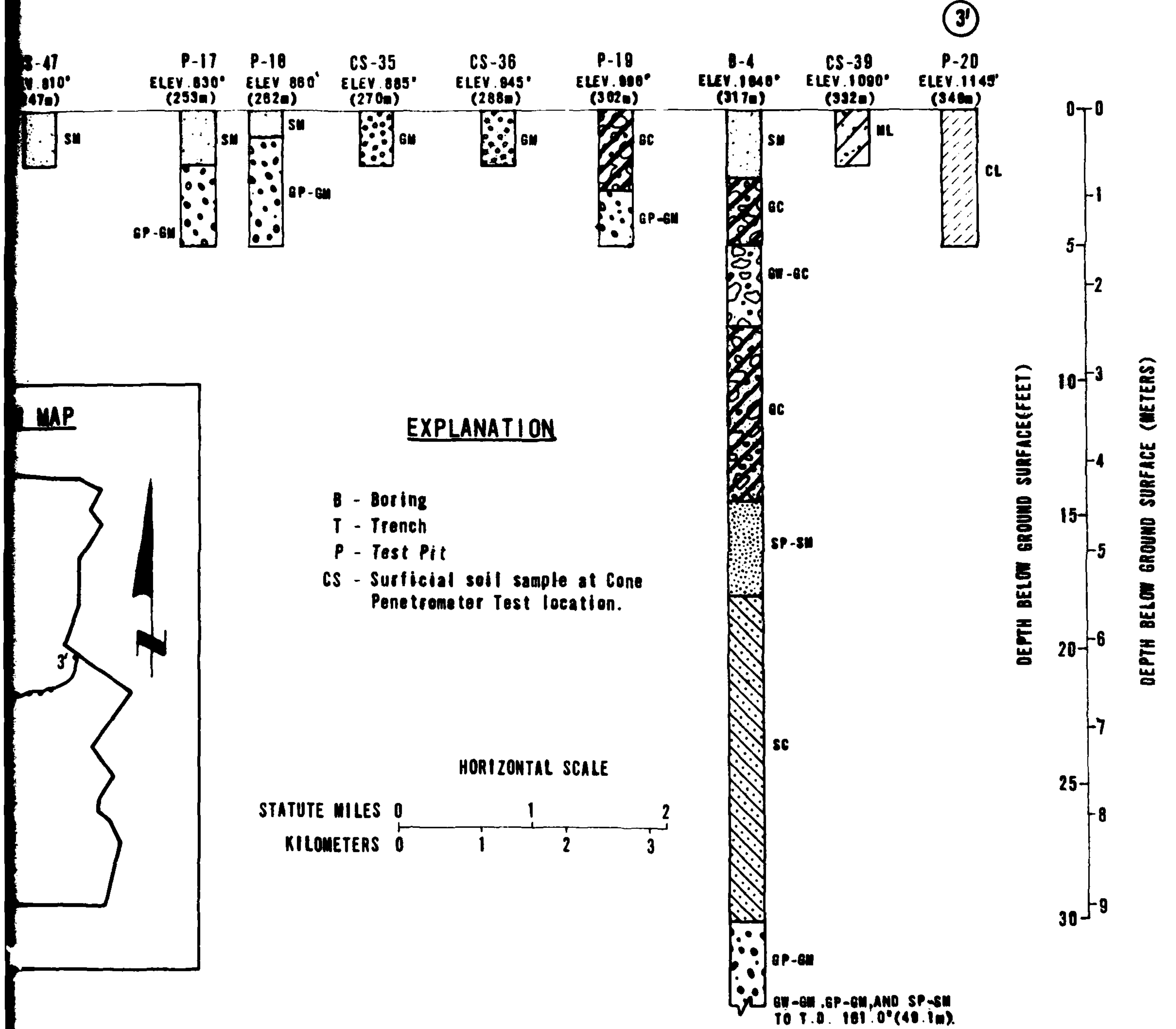
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	FIGURE 3-4

FUGRO NATIONAL, INC.



NOTES:

1. Ground s
2. T.D. = To
3. Soil typ
Classifi



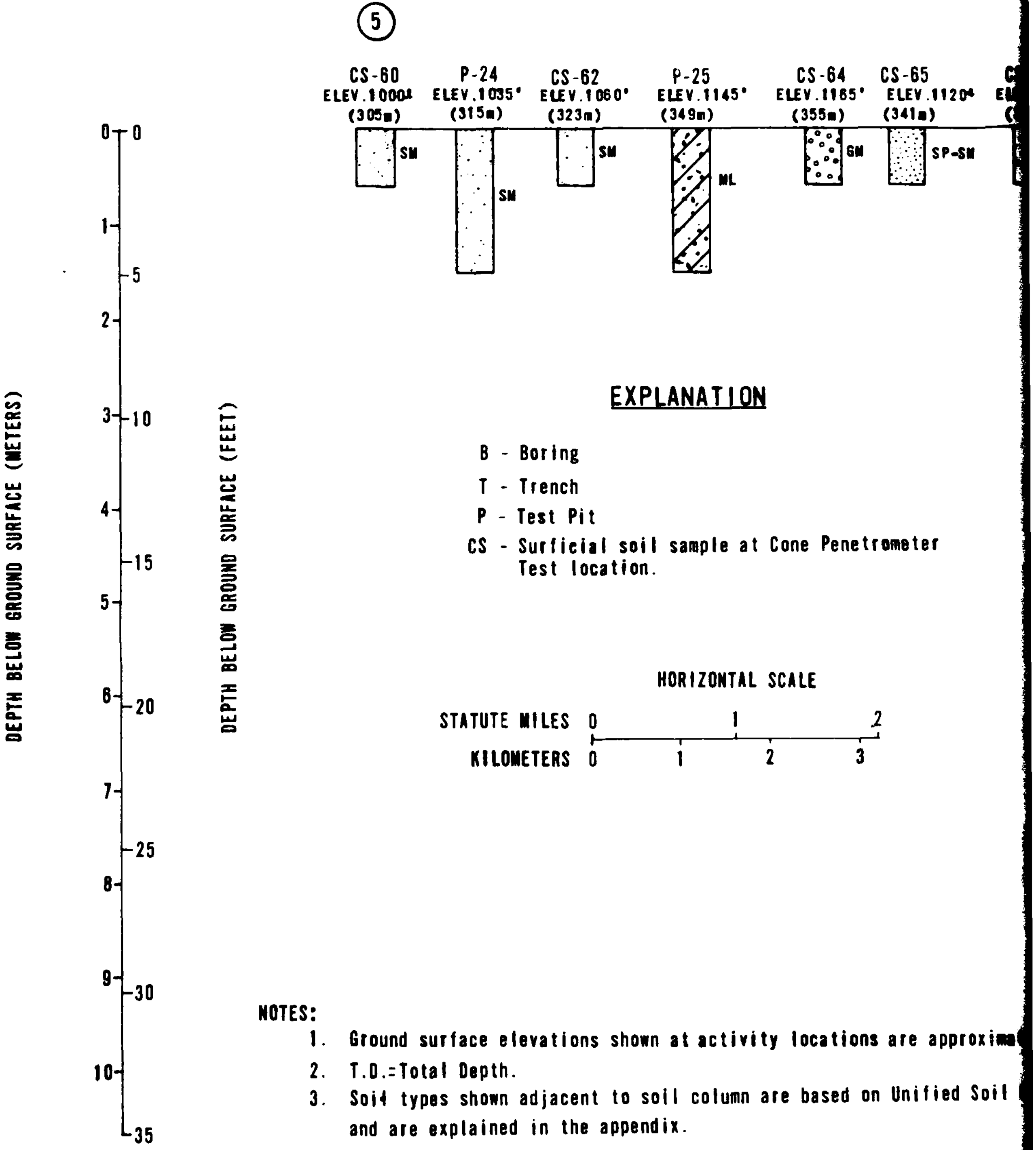
...und surface elevations shown at activity locations are approximate.
...= Total Depth.
...l types shown adjacent to soil column are based on Unified Soil ...ssification System (USCS) and are explained in the appendix.

SOIL PROFILE 3-3'
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 3-5

FUGRO NATIONAL, INC.



EXPLANATION

B - Boring

T - Trench

P - Test Pit

CS - Surficial soil sample at Cone Penetrometer Test location.

HORIZONTAL SCALE

STATUTE MILES 0 1 2

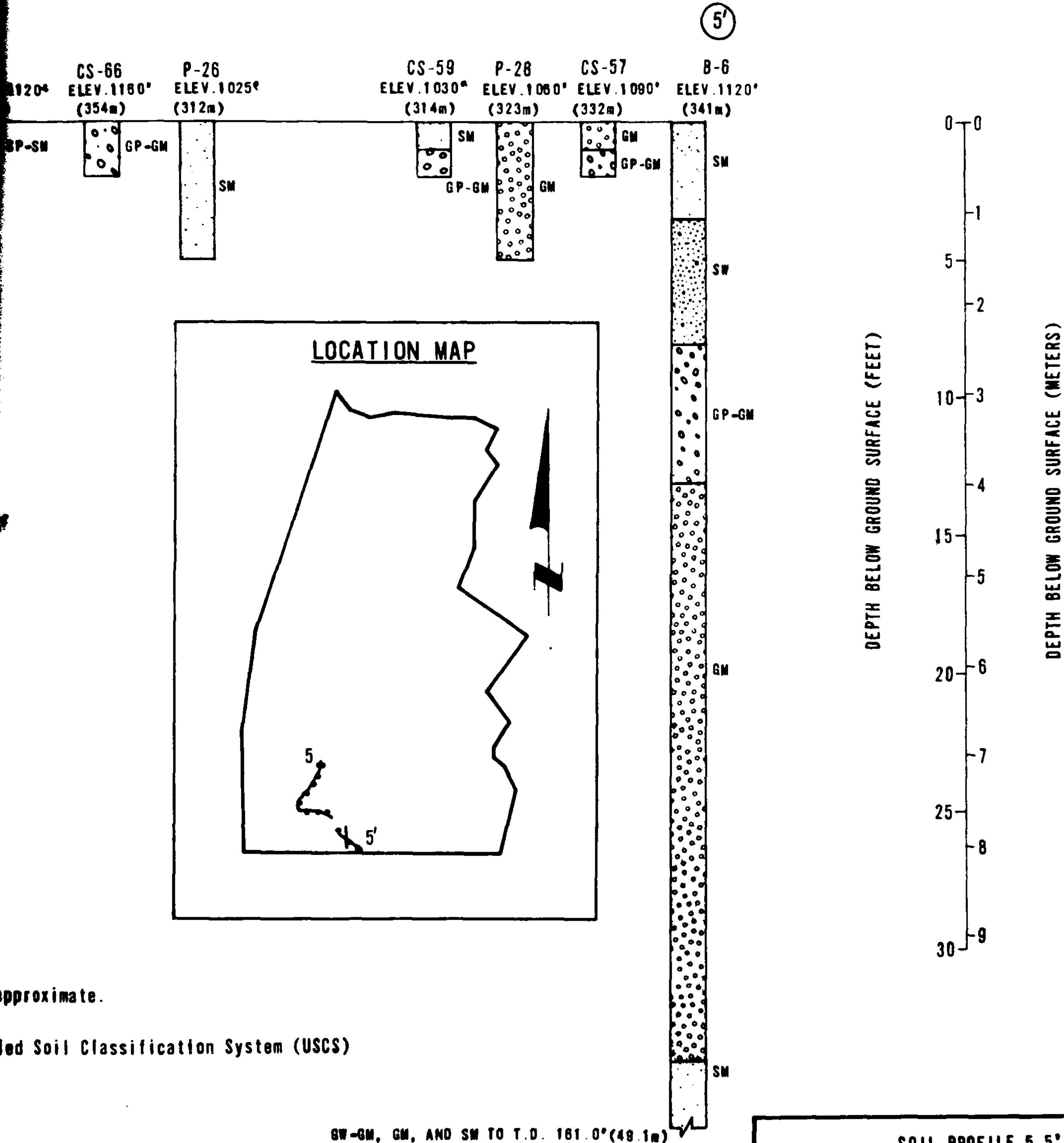
KILOMETERS 0 1 2 3

NOTES:

1. Ground surface elevations shown at activity locations are approxima

2. T.D.=Total Depth.

3. Soil types shown adjacent to soil column are based on Unified Soil and are explained in the appendix.



approximate.

fied Soil Classification System (USCS)

SOIL PROFILE 5-5'
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

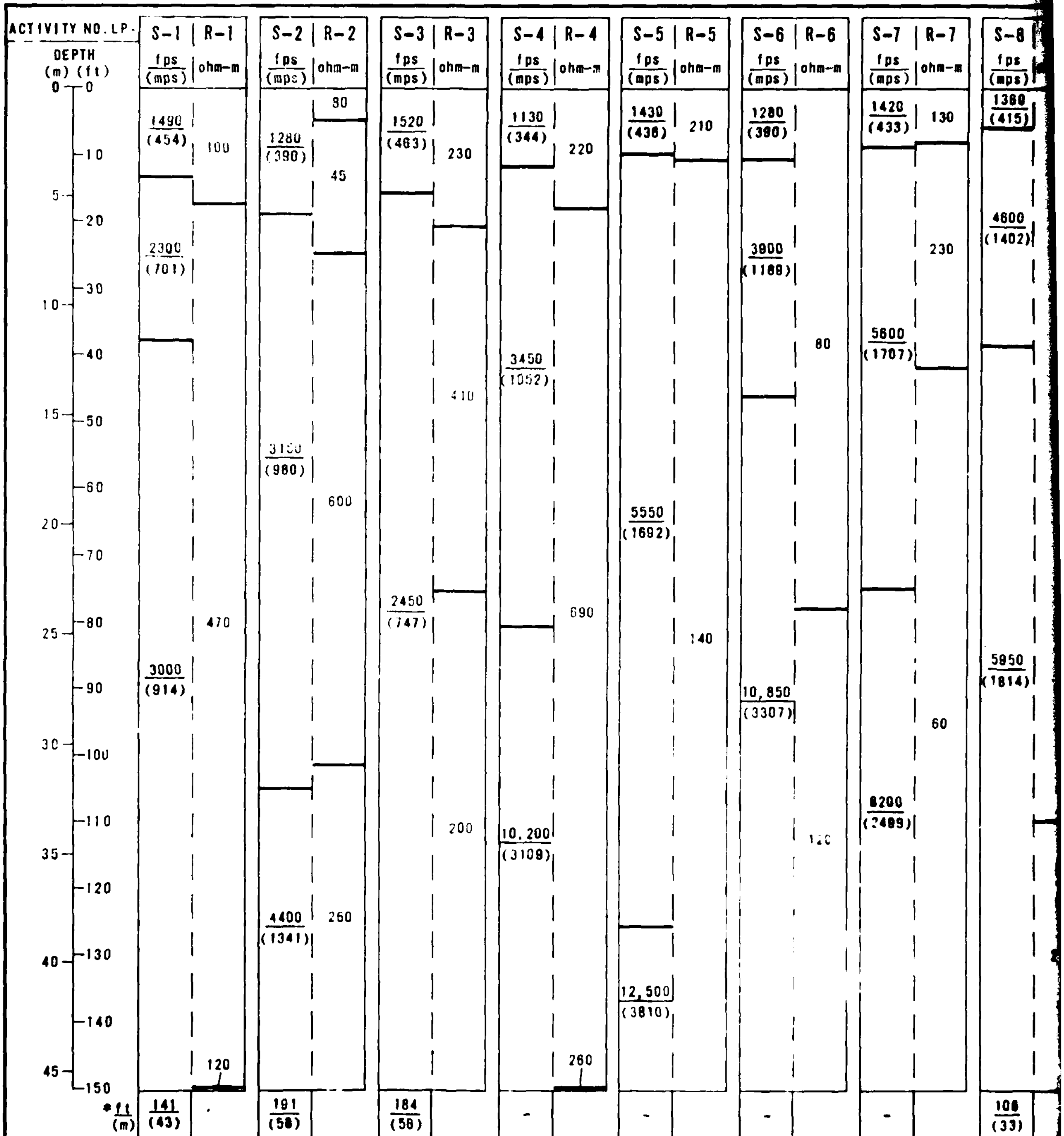
FIGURE 3-6

FUGRO NATIONAL, INC.

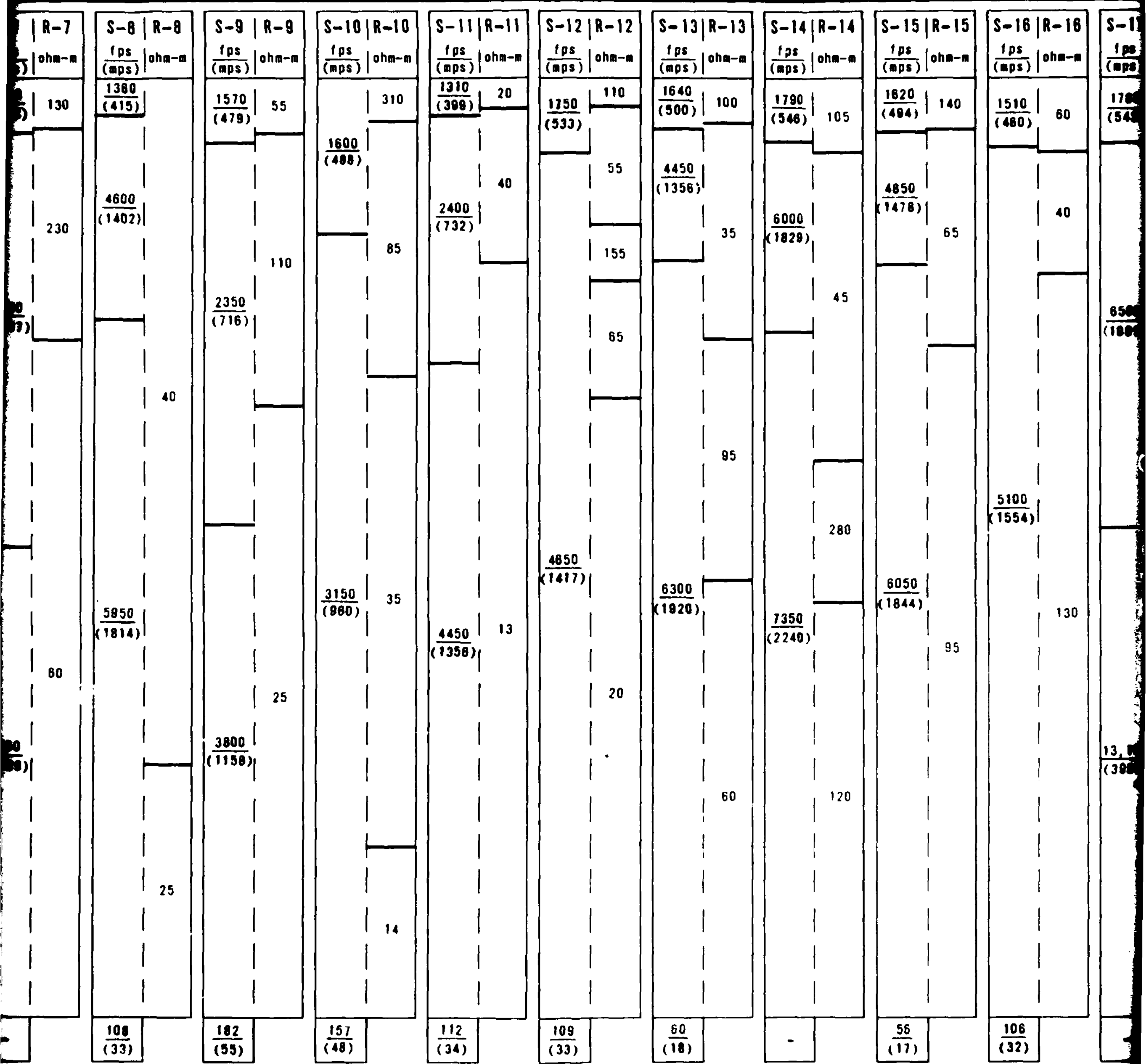
and silty sands are predominant in the north one-third of the site. These deposits are shallow eolian sands which are apparently underlain by massive terraces (A2). Coarser granular soils, predominantly of intermediate fans (A5i), overlie the finer terrace sands in the central portion of the site. The fan deposits are generally heterogeneous mixtures of coarse to fine gravelly and/or silty sand and sandy gravel with minor silt or clay interbeds. In the southern third of the site, coarser granular soils, either of intermediate fans or recent stream channel deposits (A1), are continuous to at least 160 feet (49 m).

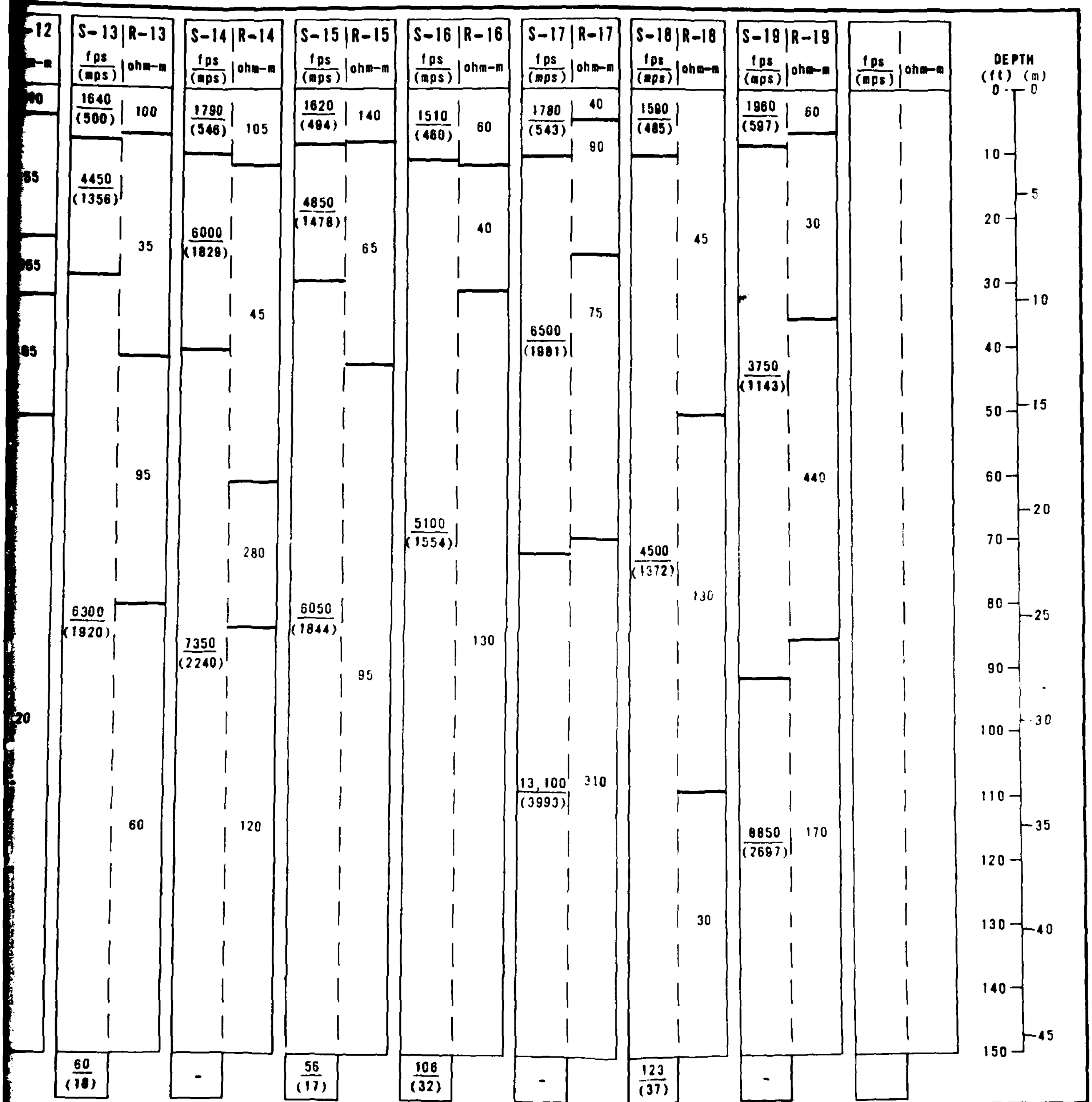
Results of seismic refraction and electrical resistivity surveys are summarized in Table 3-4. Characteristics of subsurface soils, as determined from field and laboratory tests, are presented in Table 3-5. Gradation ranges of subsurface soils are shown in Figure 3-7.

The fine to medium eolian and terrace sands are medium dense to dense to approximately 20 feet (6 m) and dense to very dense at increased depth. Below 20 feet, these soils possess moderate to high shear strengths and have a seismic wave velocity range between 2300 and 4400 fps (701 and 1341 mps). Thin layers with variable calcium carbonate cementation occur intermittently, but well-developed, continuous cementation is not present. The coarser, granular soils of intermediate alluvial fans are dense to very dense below 10 feet (3 m), exhibit low compressibilities, and possess moderate to high shear strengths.



* Approximate depth above which there is no indication of material with a velocity as great as 7000 fps (2134 mps). See Appendix A for an explanation of how this exclusion depth is calculated when the observed velocities are all less then 7000 fps (2134 mps).


R-7
ohm-m
130
230
80
S-8 | R-8
fps (mps) | ohm-m
1360 (415)
4600 (1402)
40
5850 (1814)
25
108 (33)
S-9 | R-9
fps (mps) | ohm-m
1570 (479)
55
110
2350 (716)
25
3800 (1158)
182 (55)
S-10 | R-10
fps (mps) | ohm-m
310
1600 (488)
85
3150 (960)
35
14
157 (48)
S-11 | R-11
fps (mps) | ohm-m
1310 (399)
20
40
2400 (732)
4450 (1356)
13
112 (34)
S-12 | R-12
fps (mps) | ohm-m
1750 (533)
110
55
155
65
4650 (1417)
20
109 (33)
S-13 | R-13
fps (mps) | ohm-m
1640 (500)
100
4450 (1356)
35
95
6300 (1920)
60
60 (18)
S-14 | R-14
fps (mps) | ohm-m
1790 (546)
105
6000 (1829)
45
280
7350 (2240)
120
S-15 | R-15
fps (mps) | ohm-m
1620 (494)
140
4850 (1478)
65
6050 (1844)
95
56 (17)
S-16 | R-16
fps (mps) | ohm-m
1510 (460)
60
40
5100 (1554)
130
106 (32)



SEISMIC REFRACTION AND
ELECTRICAL RESISTIVITY
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE SAMSO	TABLE 3-4

FUGRO NATIONAL, INC.

AFV-18

DEPTH RANGE	2' - 20' (0.6 - 6.0m)		
SOIL DESCRIPTION	Coarse-grained soils		Fin
	Sandy Gravels, Gravelly Sands, Sands, and Silty Sands		Sandy Si
USCS SYMBOLS	GW, GP, GM, GC, SW, SP, SM, and SC		ML and CL
ESTIMATED EXTENT IN SUBSURFACE %	90-95		5-10
PHYSICAL PROPERTIES			
DRY DENSITY pcf (kg/m³)	91.3-128.5 (1462-2058)	[21]	96.1 (1539)
MOISTURE CONTENT %	2.0-14.1	[23]	4.3
DEGREE OF CEMENTATION	none to moderate		moderate t
COBBLES 3 - 12 inches (8 - 30 cm) %	0-10		0
GRAVEL %	0-60	[14]	0
SAND %	32-91	[14]	45
SILT AND CLAY %	3-27	[14]	55
LIQUID LIMIT	NDA		NDA
PLASTICITY INDEX	NDA		NDA
COMPRESSIONAL WAVE VELOCITY fps (mps)	1130-5600 (344-1707)	[19]	NDA
SHEAR STRENGTH DATA			
UNCONFINED COMPRESSION S_u - ksf (kN/m²)	NDA		NDA
TRIAXIAL COMPRESSION c - ksf (kN/m²), ø°	NDA		NDA
DIRECT SHEAR c - ksf (kN/m²), ø°	C = 0-0.5 (0-24) ø = 33°-41°	[9]	NDA

NOTES:

- Characteristics of soils between 2 and 20 feet (0.6 and 6.0 meters) are based on results of tests on samples from 6 borings, 5 trenches, and 28 test pits, and results of 18 seismic refraction surveys.
- Characteristics of soils below 20 feet (6.0 meters) are based on results of tests on samples from 6 borings and results of 18 seismic refraction surveys.

- [ ]
- NDA -

.6 - 6.0m)	20' - 160' (6.0 - 49.0m)	
Fine-grained soils	Coarse-grained soils	Fine-grained soils
Sandy Silt and Sandy Clay	Sandy Gravel, Gravelly Sand, Sand and Silty Sand	Clay
ML and CL	GW, GP, GM, SP, SM, and SC	CH
5-10	95-100	0-5
96.1 (1539) [1]	95.0-131.4 (1522-2105) [70]	91.0-91.4 (1458-1464) [2]
4.3 [1]	1.4-23.6 [70]	31.4-33.3 [2]
moderate to strong	none to moderate	none to moderate
0	0-10	0
0 [1]	0-49 [32]	0 [1]
45 [1]	28-99 [32]	3 [1]
55 [1]	1-37 [32]	97 [1]
NDA	63 [1]	79 [1]
NDA	32 [1]	58 [1]
NDA	2300-6050 (701-1844) [18]	NDA
NDA	NDA	6.5 (311) [1]
NDA	Ø 37°-41° [2]	NDA
NDA	C = 0-0.7 Ø = 33°-38° (0-34) [9]	NDA

- [ ] - Number of tests performed.
- NDA - No data available (insufficient data or tests not performed.)

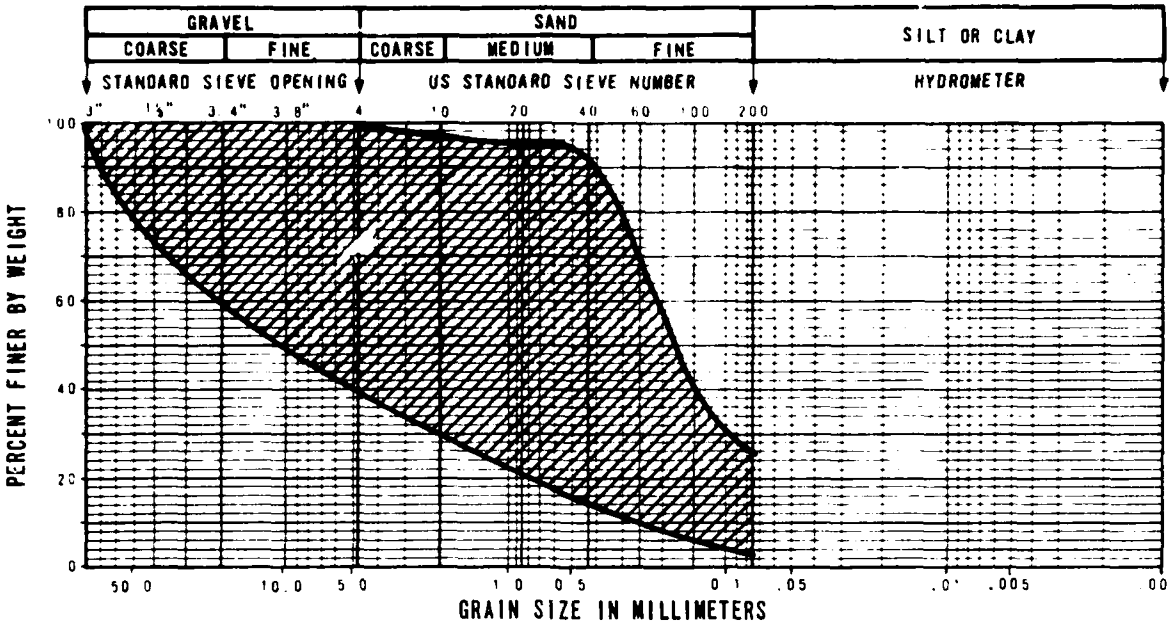
CHARACTERISTICS OF SUBSURFACE SOILS VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

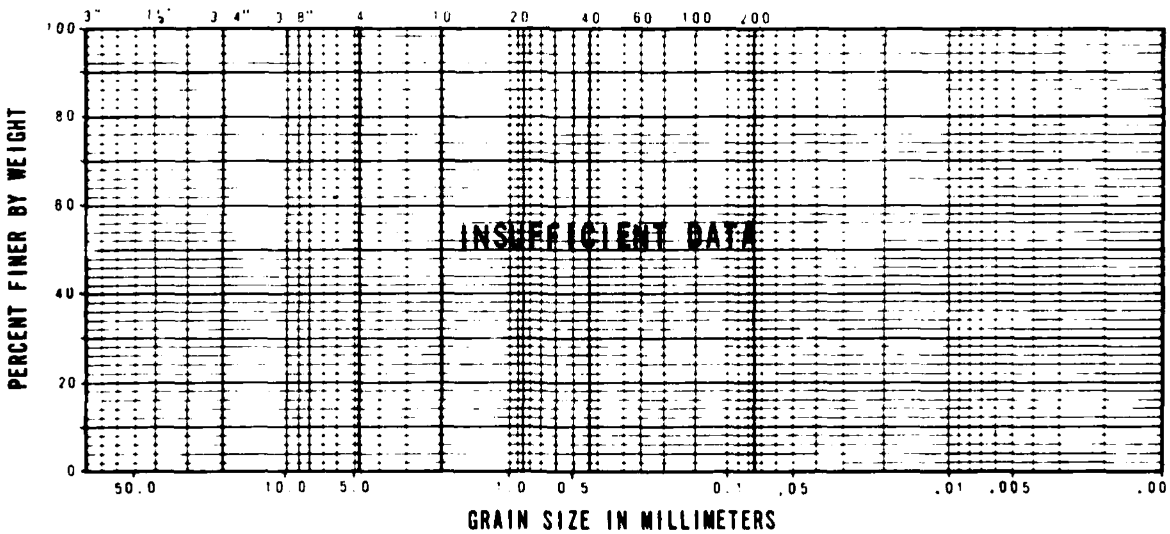
TABLE 3-5

FUGRO NATIONAL, INC.

AFV-



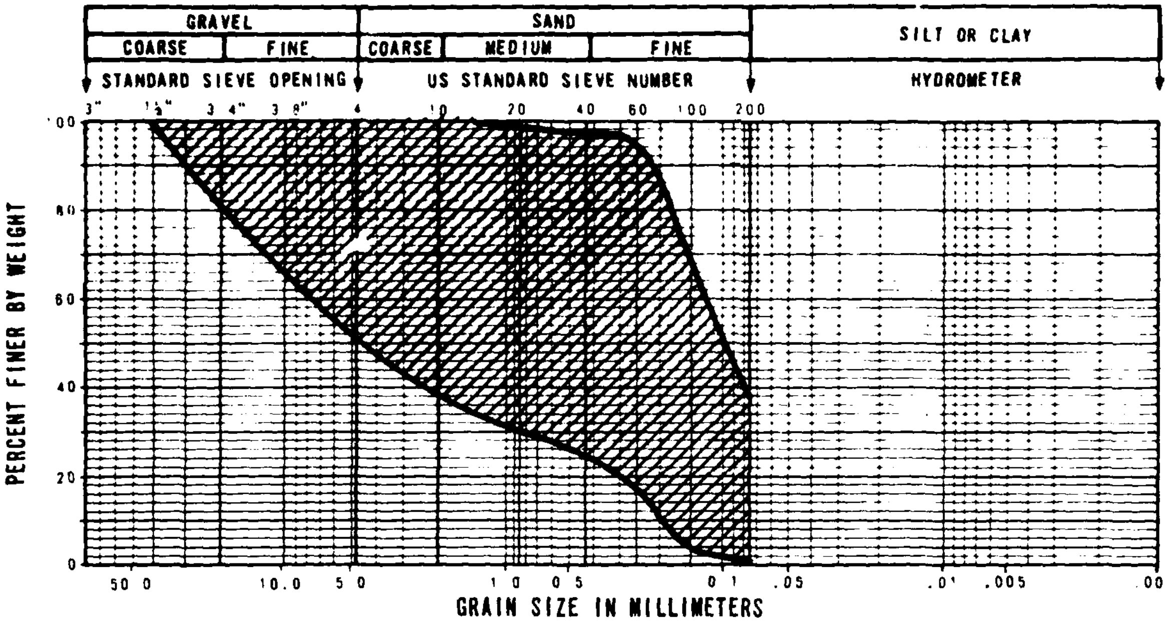
SOIL DESCRIPTION: Coarse-grained soils from 2 to 20 feet (0.6 to 6m)



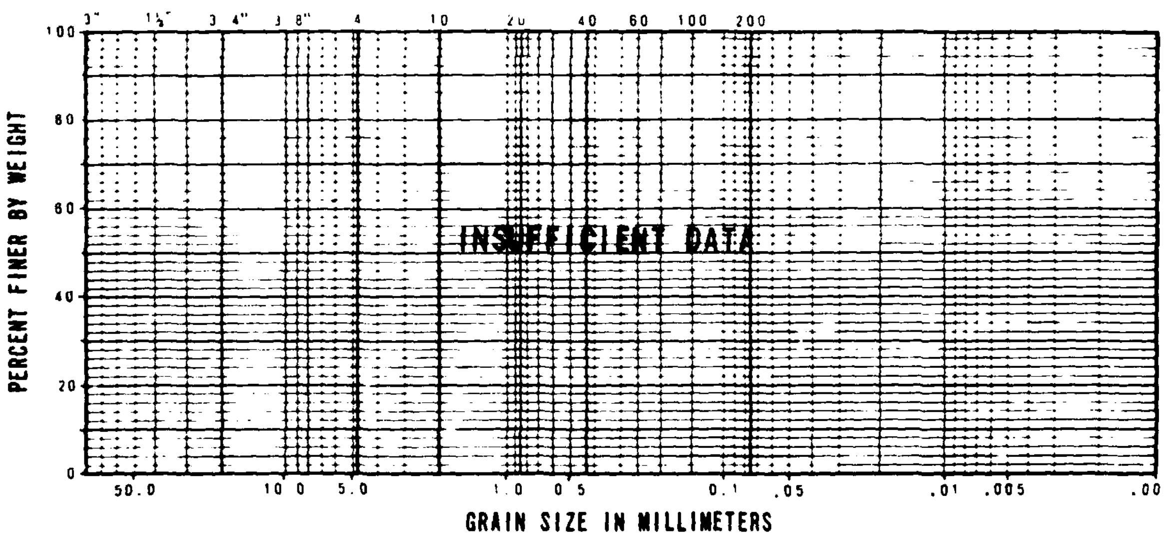
SOIL DESCRIPTION: Fine-grained soils from 2 to 20 feet (0.6 to 6m)

RANGE OF GRADATION OF SUBSURFACE SOILS VERIFICATION SITE, LA POSA CDP, ARIZONA	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE SAMSO	FIGURE 3-7 1 OF 2

FUGRO NATIONAL, INC.



SOIL DESCRIPTION: Coarse-grained soils from 20 to 160 feet (6 to 49m)



SOIL DESCRIPTION: Fine-grained soils from 20 to 160 feet (6 to 49m)

RANGE OF GRADATION OF SUBSURFACE SOILS
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 3-7

FUGRO NATIONAL, INC.

Calcium carbonate cementation is often well developed in the upper 20 feet but intermittent at increased depth. Seismic wave velocities range between 2350 and 6050 fps (716 and 1844 mps), significantly higher than measured in the fine to medium eolian sands, indicating increased density and cementation.

Fine-grained soils occur as sporadic silt or clay interbeds, generally in intermediate alluvial fans. These soils are stiff to hard and possess moderate to high shear strength. Their plasticity range is from slight to high.

Electrical resistivity profiles for the La Posa site do not indicate any systematic mineralogic or moisture content changes with increasing depth. Electrical conductivity of the soils in the upper 50 feet (15 m) ranges from 0.0019 to 0.0375 mhos per meter (average 0.0121 mhos per meter). At four of the 19 locations tested, conductivity was less than the minimum of 0.004 mhos per meter specified in the Fine Screening criteria. The locations with conductivities below the minimum were all in the northern third of La Posa. Chemical test results indicate negligible to considerable potentials for sulfate attack of soils on concrete.

3.6 TERRAIN

Terrain conditions are depicted in Drawing 3-3. Relief is developed primarily on west-sloping alluvial fan surfaces of intermediate age (terrain category II). Terrain category I corresponds to areas in northern La Posa covered by eolian sand. Other terrain categories relate to various depths of

incision on intermediate alluvial fan deposits. Older alluvial fan deposits and highly dissected deposits along major entrenched streams (Bouse Wash and Tyson Wash) generally constitute unsuitable terrain (category VII).

La Posa CDP ranges from 910 feet (278 m) in elevation at the base of the Plomosa Mountains to a low of 500 feet (153 m) in Tyson Wash at the western edge of the site. Drainage is to the west via Bouse Wash into the Colorado River in northern La Posa, and is north via Tyson Wash and then west into the Colorado River in southern La Posa.

In southern La Posa, depths of incision on intermediate alluvial fan deposits are generally from 3 to 10 feet (1 to 3 m) with a spacing of from 8 to 12 drainages per mile (terrain categories II and III). Slopes range from 0 to 2 percent with an average of less than 1 percent. In northern La Posa, the slopes are similar but drainage incision is less (less than 3 feet; 1 m) and spacing is much wider (1 to 3 drainages per mile) due to the presence of eolian sand at the surface. Terrain exclusion areas occur around the site periphery and constitute approximately 5 percent of the area.

3.7 DEPTH TO ROCK

Generalized contours depicting depth to rock are shown in Drawing 3-4. All data used in constructing the map are shown. Rock was detected along seven seismic lines, giving limited control on depth to rock around the periphery of the site. Only calculated minimum depths to rock were acquired in the

remaining seismic lines. These data generally indicate a steeply dipping mountain front with little shallow rock except in deeply embayed areas with numerous outliers. Spacing of 50-foot (15-m) and 150-foot (46-m) contours in areas where no data are available is based on a projection of the topographic slope into the subsurface.

Principal areas of shallow rock occur in northern La Posa along the Plomosa Mountains, where Tertiary sedimentary rocks have been extensively pedimented (Jemmett, 1966), and elsewhere around the site periphery in valley reentrants. Rock at less than 50 feet constitutes approximately 8 to 10 percent of the site area, and rock at depths from 50 to 150 feet is estimated to cover 5 percent of the site.

3.8 DEPTH TO WATER

Drawing 3-5 shows the approximate configuration of the 50-foot (15-m) and 150-foot (46-m) depth to water contours at the La Posa Site. These contours represent water levels in the unconfined basin-fill aquifer. Data are concentrated in southern La Posa, particularly near Quartzsite but are very sparse in other parts of the site. Water-level measurements are relatively current and are taken from Metzger et al. (1973) and USGS (1975, 1978a, 1978b, 1979). The 150-foot contour is more approximate than the 50-foot contour because of the lack of wells reporting levels at or around the 150-foot depth. Control on the 50-foot contour is good in the vicinity of Quartzsite but is poor elsewhere.

Water occurs at depths greater than 150 feet throughout northern and eastern La Posa. Shallow water is present principally along Tyson Wash on the eastern flank of the Dome Rock Mountains. Water at less than 150 feet occurs over much of the southwestern part of the site and is the source of water for the town of Quartzsite and for the vigorous winter recreational activity in southern La Posa. Metzger et al. (1973) and Loeltz (1979) indicate that the ground-water table in the vicintiy of Quartzsite is probably perched. Water at less than 50 feet (15 m) constitutes about 6 percent and water at less than 150 feet (46-m) and greater than 50 feet (15-m) constitutes an additional 14 percent of the site area.

3.9 RESULTS AND CONCLUSIONS

3.9.1 Suitable Area

Resulting suitable area as defined by FY 79 Verification studies in the La Posa site is shown in Drawing 3-6. The site contains approximately 300 mi^2 (775 km^2) of usable area for a hybrid trench or horizontal shelter and 230 mi^2 (600 km^2) for a vertical shelter concept. These results are slightly less than reported in previous Intermediate/Fine Screening studies due to:

1. Additional terrain exclusions in northern and western La Posa;
2. Additional shallow rock exclusions distributed uniformly around the site periphery; and
3. Expansion of shallow water exclusions along Tyson Wash.

3.9.2 Construction Considerations

In this section, geotechnical factors and conditions which would affect the construction of the MX system in the suitable area are discussed. Both the hybrid trench and vertical shelter basing modes are considered.

3.9.2.1 Grading

Surficial slopes in the La Posa site range from 0 to 4 percent (average about 2 percent), thus requiring limited preconstruction grading for roads and trenches.

3.9.2.2 Roads

Surficial soils exhibit low strength to an average depth of 2.4 feet (0.7 m), with a maximum depth approaching 11 feet (3.4 m). The subgrade supporting properties of low-strength, coarse-grained soils are inadequate but can be improved by mechanical compaction. Compaction to a depth between 1 to 3 feet (0.3 to 0.9 m) appears necessary for most areas with deeper compaction possibly required for the eolian sands of northern La Posa. Based on results of laboratory CBR tests, compacted coarse-grained soils will provide good to very good subgrade support for roads in southern La Posa and poor to fair support in northern La Posa.

The eolian sands of northern La Posa create some road design and construction problems not encountered in other Arizona sites. At 90 percent relative compaction, these sands have low CBR values (<15); however CBR values higher than 15 are obtained at

95 percent relative compaction. Subgrade improvement techniques for these sands include: compaction to 95 percent; blending (mixing) with coarser gravelly sands to improve gradation; cement or bituminous stabilization; and using a select granular subbase layer to confine the compacted, eolian sand subgrade. Vehicle trafficability across the eolian sands will be poor until a stabilized roadbed is obtained.

Few roadway sections will be underlain by fine-grained soils due to their infrequent presence in the surficial zone. Where present, fine-gained soils will probably be inadequate for direct support of roadways. Therefore, required support can be attained by using a select granular subbase layer over the compacted fine-grained soil subgrade. As an alternative, fine-grained soils could be partially or totally removed, depending upon their thickness, and replaced by a sufficient thickness of coarse-grained soil to obtain the required subgrade support.

Coarse gravelly sands or sandy gravels from intermediate aluvial fan and recent channel deposits in the southern half of the site will prove suitable as a subbase material when the fines content (passing a No. 200 sieve) is less than 25 percent. Gravels or gravelly sands with a wide distribution of particle sizes and minimal fines may prove acceptable as a source for processed base course materials. Such materials are widely distributed in active channels (Tyson Wash, Bouse Wash, and numerous minor drainages) and are presently being mined near Quartzsite for aggregate.

Average incision depths are less than 3 feet (1 m) in northern La Posa and generally range between 3 and 10 feet (1 and 3 m) in southern La Posa. Incisions locally exceed 10 feet (3 m) in gravelly deposits near mountain fronts and along major drainages. Thus, the overall cost of drainage structures will probably be low to moderate.

3.9.2.3 Excavatability and Stability

Subsurface soils in the suitable site area are predominantly coarse-grained with fine-grained soils estimated in less than 10 percent of the construction zone. Subsurface soils are generally dense to very dense below 10 feet (3 m) in the southern portion and below 20 feet (6 m) in the north. Variable cementation is present in all areas but more well developed in southern La Posa.

Hybrid Trench: Compressional wave velocities in the upper 20 feet (6 m) and observations made during backhoe excavations indicate easy to moderately difficult excavation in most of the site with difficult excavation estimated in approximately 25 percent of the suitable area. MX trenchers could be used to excavate continuous trenches for cast-in-place construction. Based on estimates of low-strength surficial soil, the upper portion of trench excavations should be sloped back for stability. Generally, sloping will be necessary to depths between 2 to 5 feet (0.6 to 1.5 m) but locally to depths approaching 10 feet (3 m) in the northern third of La Posa. Below this zone, vertical trench walls will remain temporarily stable

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MX SITING INVESTIGATION. GEOTECHNICAL EVALUATION. VOLUME I. ARI--ETC(U)
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UNCLASSIFIED FN-TR-28-VOL-1 NL

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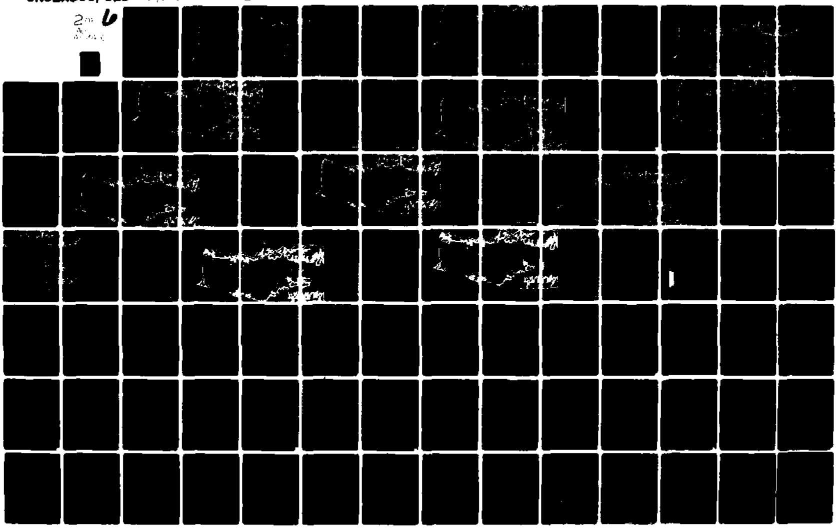

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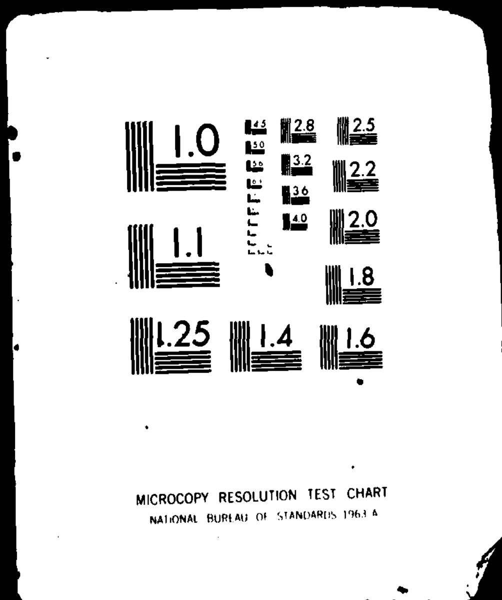

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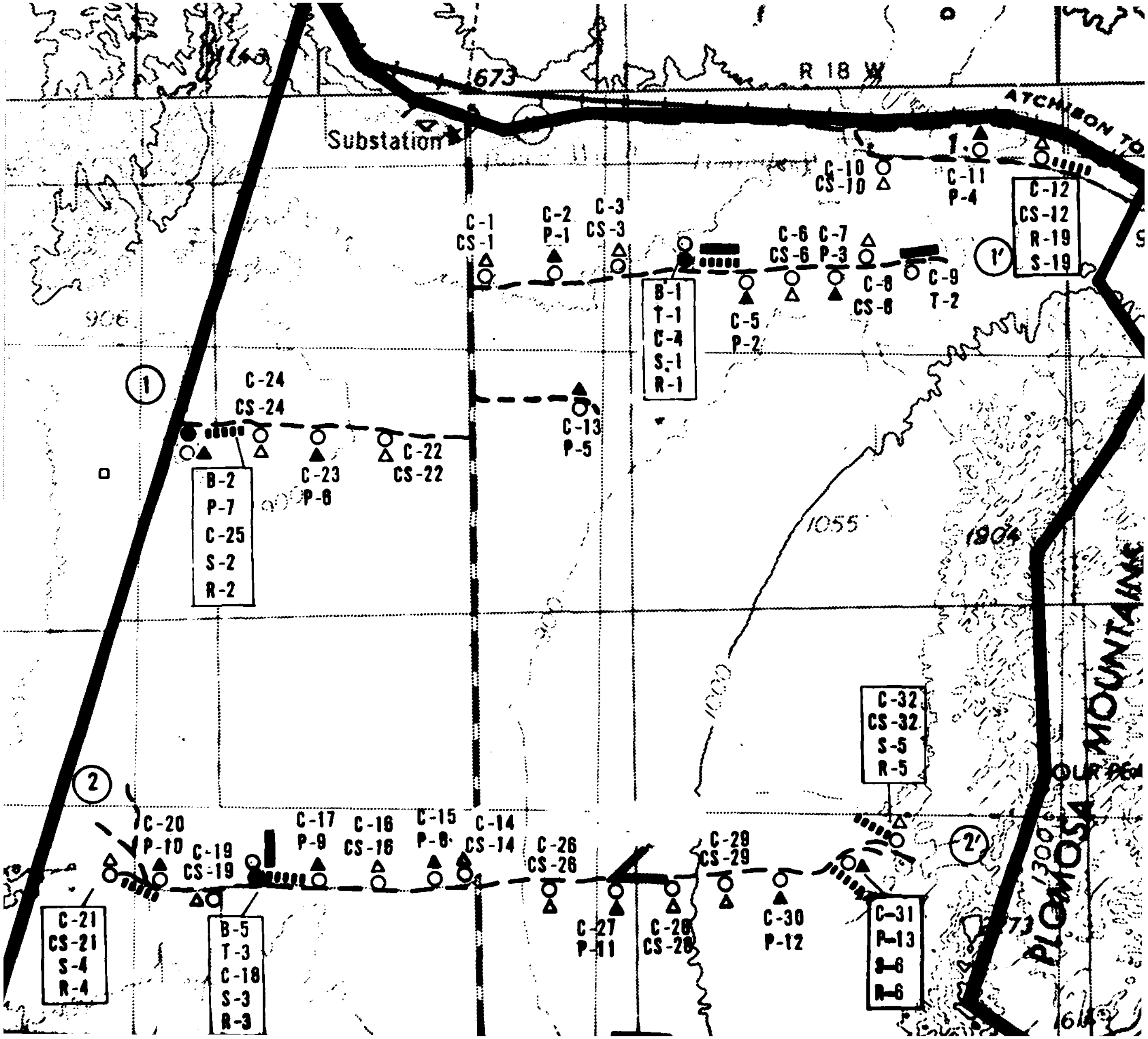
in approximately 80 percent of the suitable area. In the remaining area (mostly in the north), the apparent cohesion and/or degree of cementation of the subsurface soils may prove inadequate for temporary stability of vertical cuts. Therefore, trench walls might have to be locally shored or sloped.

Vertical Shelter: Within the depth of excavation for vertical shelters, results of our investigation indicate that large diameter augers could be used with difficult excavation expected in approximately 15 percent of the subsurface. Most excavations will be in granular soils with only intermittent cemented or cohesive soil intervals. Therefore, vertical shaft walls to depths of 120 feet (37 m) will require support or the use of a stabilizing technique.


R 18 W
673
Substation
ATCHISON TO
PLOMOSA MOUNTAINS
FOUR PEAKS
1055
1904
1300
906
1
1'
2
2'
C-1
CS-1
C-2
P-1
C-3
CS-3
B-1
T-1
C-4
S-1
R-1
C-5
P-2
C-6
CS-6
C-7
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C-9
T-2
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B-2
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C-25
S-2
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CS-19
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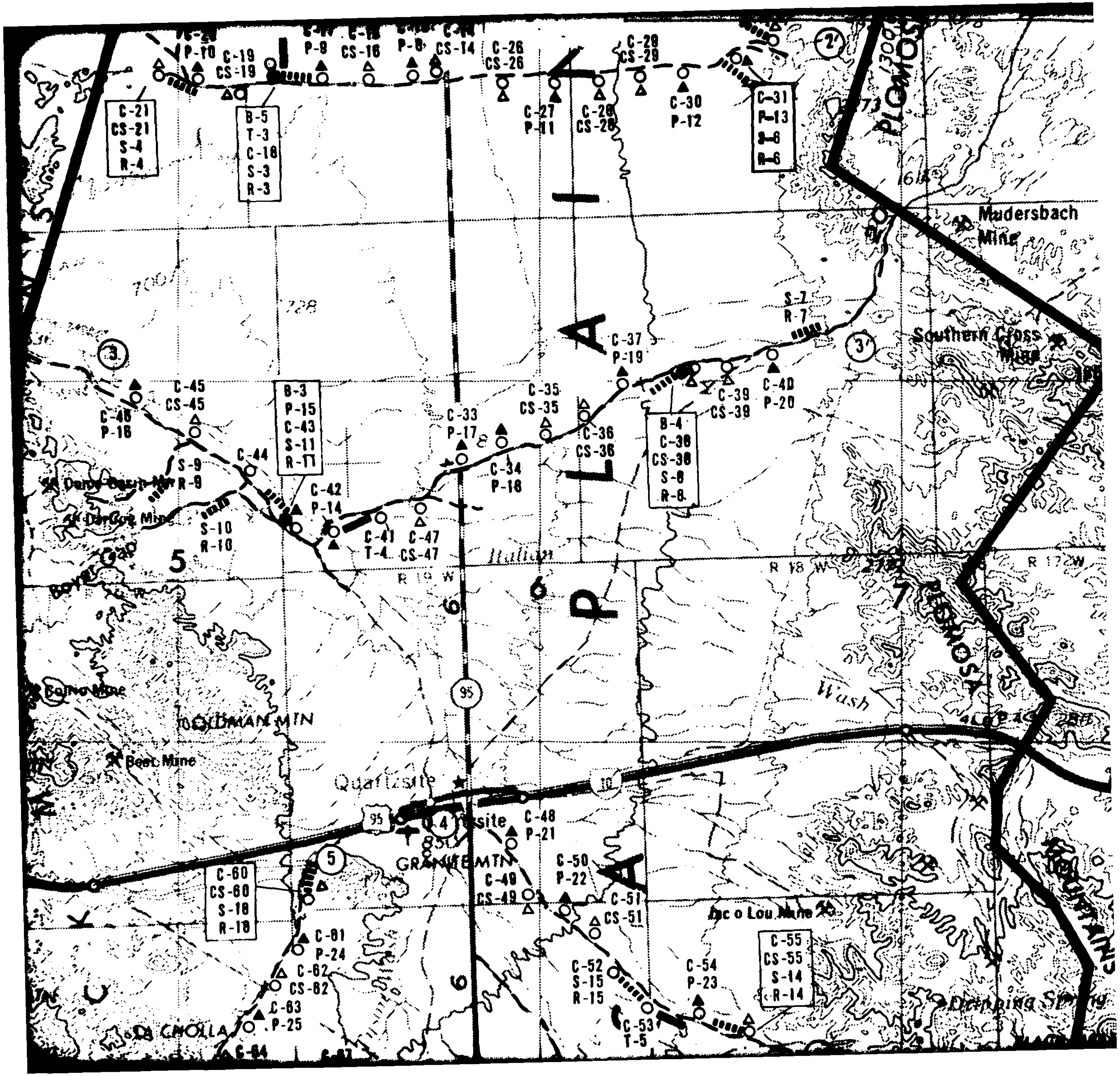
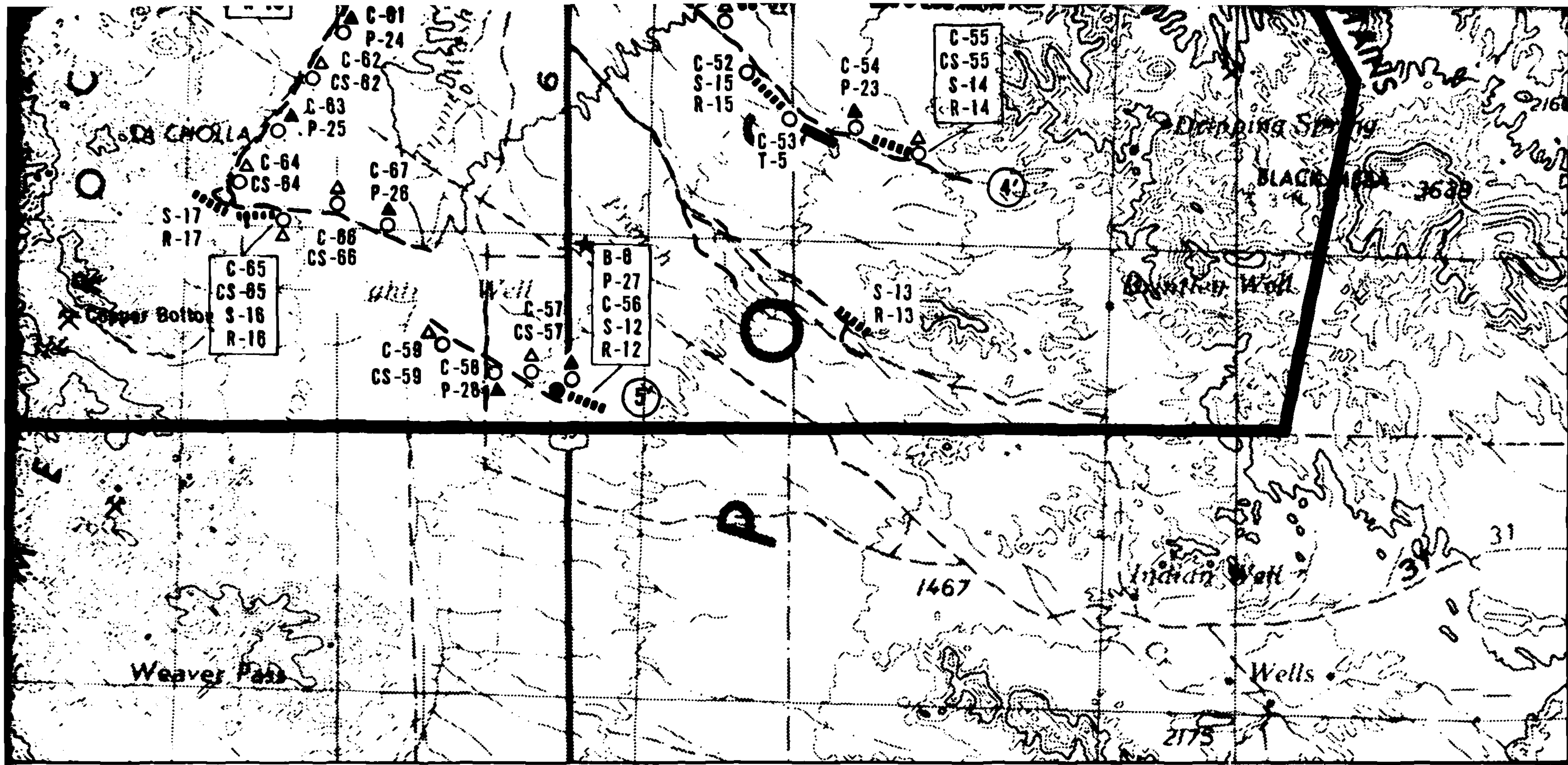
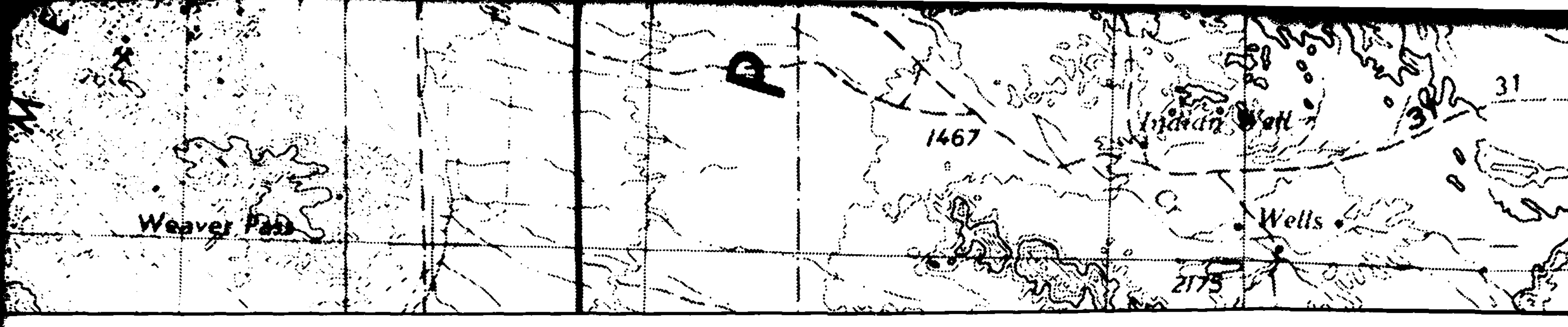
CS-32
S-5
R-5


C-21 CS-21 S-4 R-4
B-5 T-3 C-18 S-3 R-3
C-19 CS-19
CS-16
P-8 CS-14
C-26 CS-26
C-27 P-11
C-28 CS-28
C-29 CS-29
C-30 P-12
C-31 P-13 S-6 R-6
Mudersbach Mine
S-7 R-7
Southern Cross Mine
C-37 P-19
C-39 CS-39
C-40 P-20
B-4 C-38 CS-38 S-8 R-8
C-35 CS-35
C-36 CS-36
C-33 P-17
C-34 P-18
C-45 CS-45
C-46 P-16
B-3 P-15 C-43 S-11 R-11
C-44
S-9 R-9
C-42 P-14
C-41 T-4
C-47 CS-47
S-10 R-10
Italian
R 19 W
R 18 W
R 17 W
PLOMOSA
Wash
Beat Mine
Quartzsite
GRANITE MTN
C-48 P-21
C-49 CS-49
C-50 P-22
C-51 CS-51
C-60 CS-60 S-18 R-18
C-61 P-24
C-62 CS-62
C-63 P-25
C-52 S-15 R-15
C-53 T-5
C-54 P-23
C-55 CS-55 S-14 R-14
Dripping Spring
CHOLLA



EXPLANATION

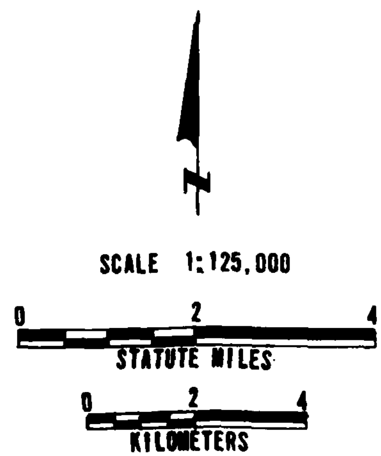
- ● B-1 BORING
- ○ C-1 CONE PENETROMETER TEST (CPT)
- △ CS-1 SURFACE SAMPLE AT CPT LOCATION
- ▬ T-1 TRENCH
- ▲ P-1 TEST PIT
- ▪▪▪▪▪ S-1 SEISMIC REFRACTION LINE; R-1 ELECTRICAL RESISTIVITY LINE
- ①- - - -① ACTIVITY LINE



EXPLANATION

- ● B-1 BORING
- ○ C-1 CONE PENETROMETER TEST (CPT)
- △ CS-1 *SURFACE SAMPLE AT CPT LOCATION*
- ▬ T-1 TRENCH
- ▲ P-1 TEST PIT
- S-1 SEISMIC REFRACTION LINE
- R-1 ELECTRICAL RESISTIVITY LINE
- (1)- - - - -(1') ACTIVITY LINE

NOTE: Where multiple activities were performed at the same location the correct location is designated by either (1) the boring symbol or (2) the CPT symbol, if no boring was drilled.



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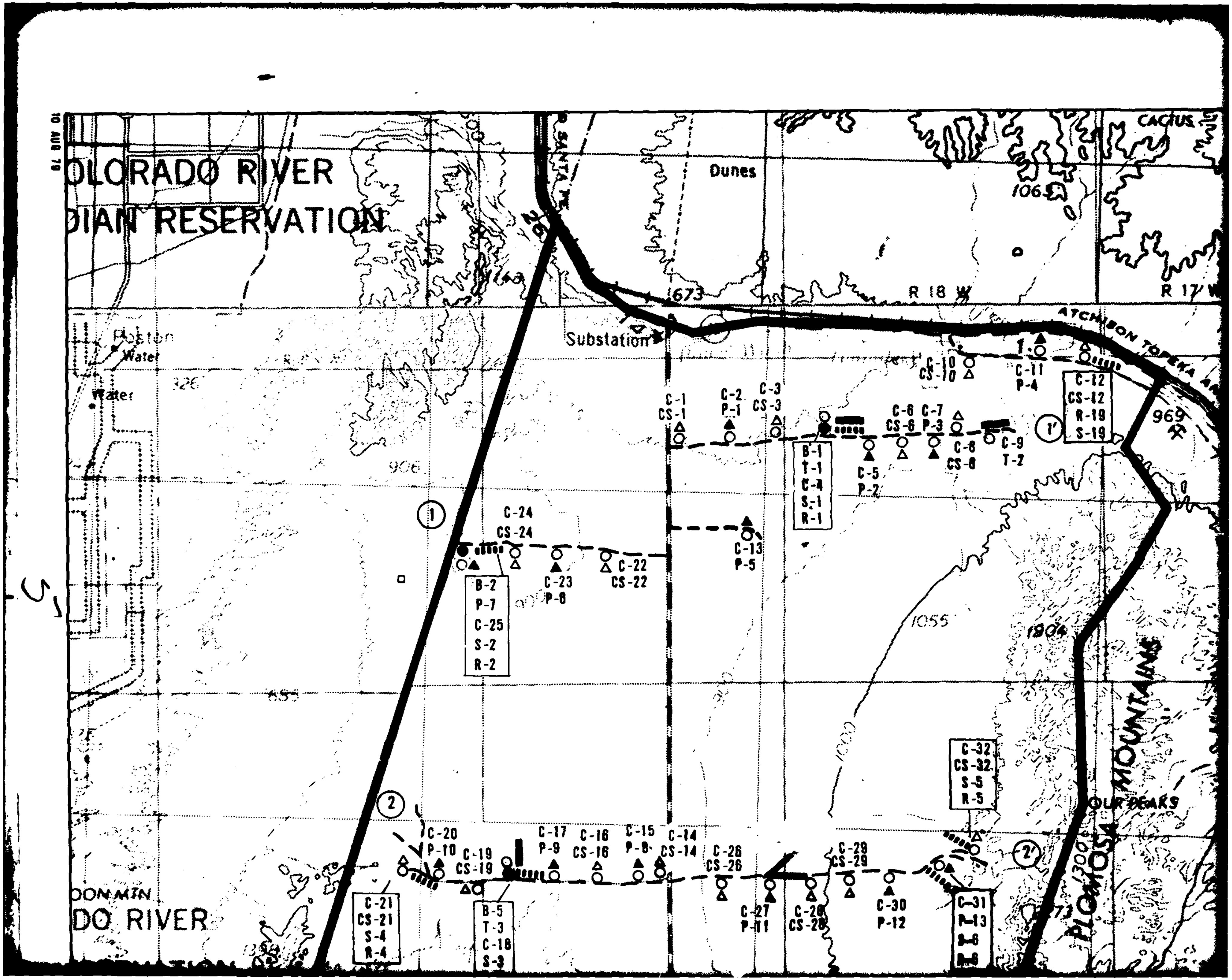

10 AUG 79
OLORADO RIVER
DIAN RESERVATION
Dunes
CACTUS
R 18 W
R 17 W
ATCHISON TOPEKA
SANTA FE
Substation
Water
Water
PLOMOSA MOUNTAINS
FOUR PEAKS
DO RIVER
C-1
CS-1
C-2
P-1
C-3
CS-3
B-1
T-1
C-4
S-1
R-1
C-5
P-2
C-6
CS-6
C-7
P-3
C-8
CS-8
C-9
T-2
C-10
CS-10
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CS-22
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P-6
C-24
CS-24
B-2
P-7
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P-10
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CS-19
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CS-21
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R-4
B-5
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C-18
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P-11
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CS-32
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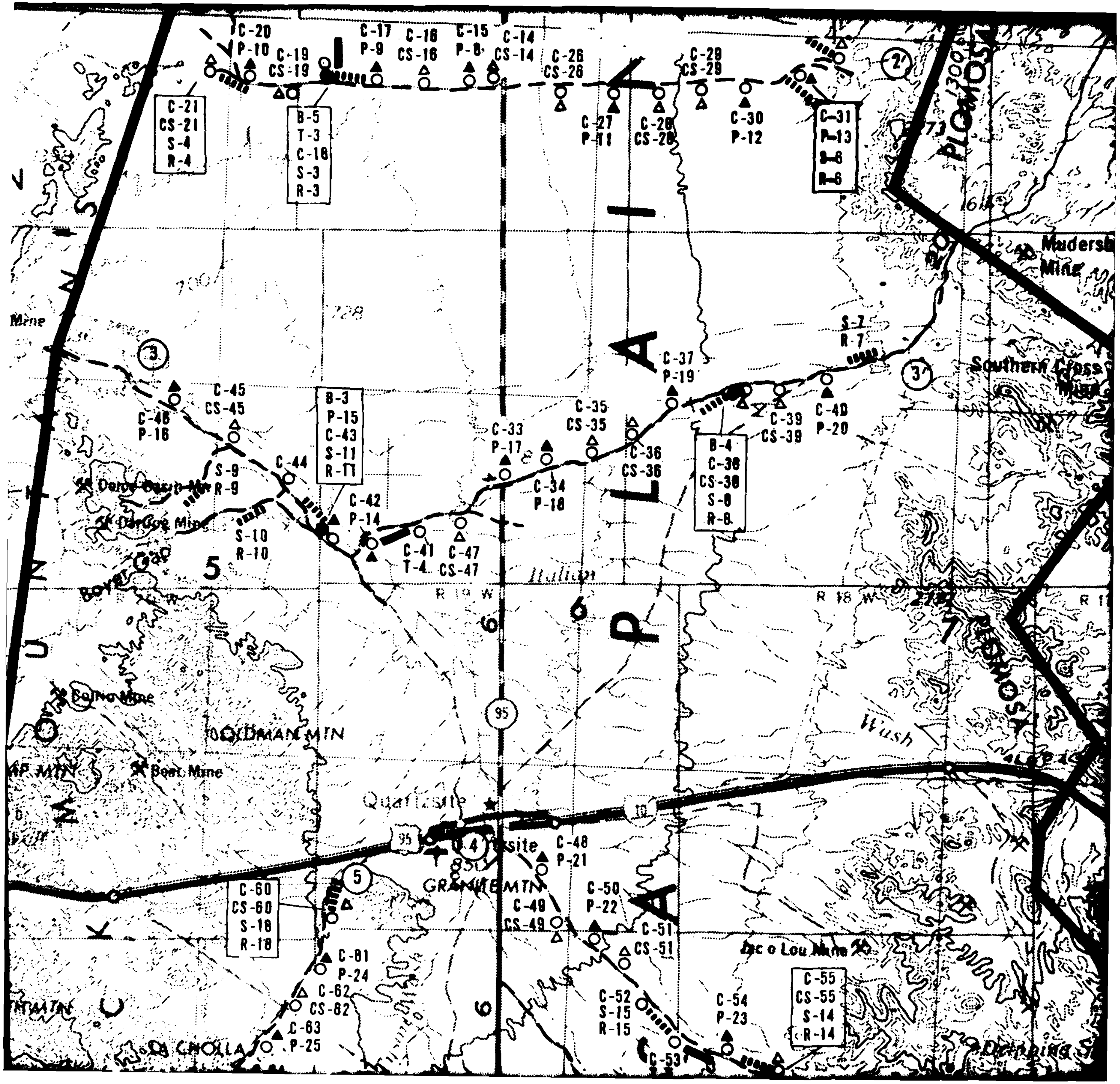
5


C-20
P-10
C-19
CS-19
C-17
P-9
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CS-16
C-15
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C-14
CS-14
C-26
CS-26
C-29
CS-29
C-21
CS-21
S-4
R-4
B-5
T-3
C-18
S-3
R-3
C-27
P-11
C-28
CS-28
C-30
P-12
C-31
P-13
S-6
R-6
PLOMOSA
Madersb
Mine
S-7
R-7
C-37
P-19
Southern Cross
Mine
C-45
CS-45
C-46
P-16
B-3
P-15
C-43
S-11
R-11
C-35
CS-35
C-33
P-17
C-44
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P-14
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CS-36
B-4
C-38
CS-38
S-8
R-8
C-39
CS-39
C-40
P-20
S-10
R-10
C-41
T-4
C-47
CS-47
R 19 W
R 18 W
Wash
95
OLDMAN MTN
Beet Mine
10
95
C-48
P-21
GRANITE MTN
C-50
P-22
C-49
CS-49
C-51
CS-51
C-60
CS-60
S-18
R-18
C-61
P-24
C-62
CS-62
C-63
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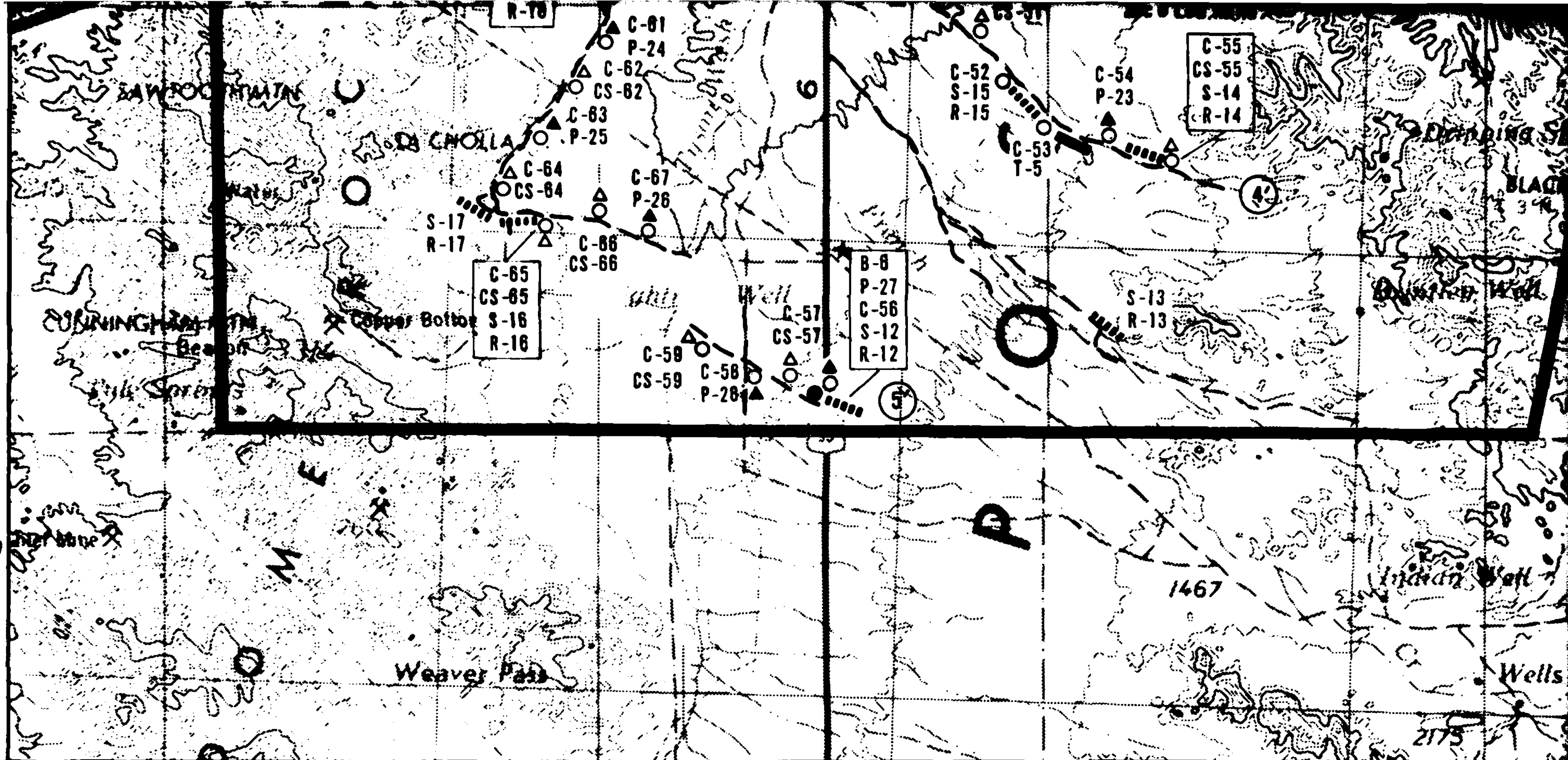
CS-55
S-14
R-14



EXPLANATION

●	B-1	BORING
○	C-1	CONE PENETROMETER TEST (CPT)
△	CS-1	SURFACE SAMPLE AT CPT LOCATION
▬	T-1	TRENCH
▲	P-1	TEST PIT
▪▪▪▪▪	S-1 R-1	SEISMIC REFRACTION LINE ELECTRICAL RESISTIVITY LINE

EXPLANATION

- ● B-1 BORING
- ○ C-1 CONE PENETROMETER TEST (CPT)
- △ CS-1 SURFACE SAMPLE AT CPT LOCATION
- ▬ T-1 TRENCH
- ▲ P-1 TEST PIT
- S-1 SEISMIC REFRACTION LINE
- R-1 ELECTRICAL RESISTIVITY LINE
- (1) - - - - (1') ACTIVITY LINE

NOTE: Where multiple activities were performed at the same location the correct location is designated by either (1) the boring symbol or (2) the CPT symbol, if no boring was drilled.

SCALE 1:125,000

0 2 STATUTE MILES

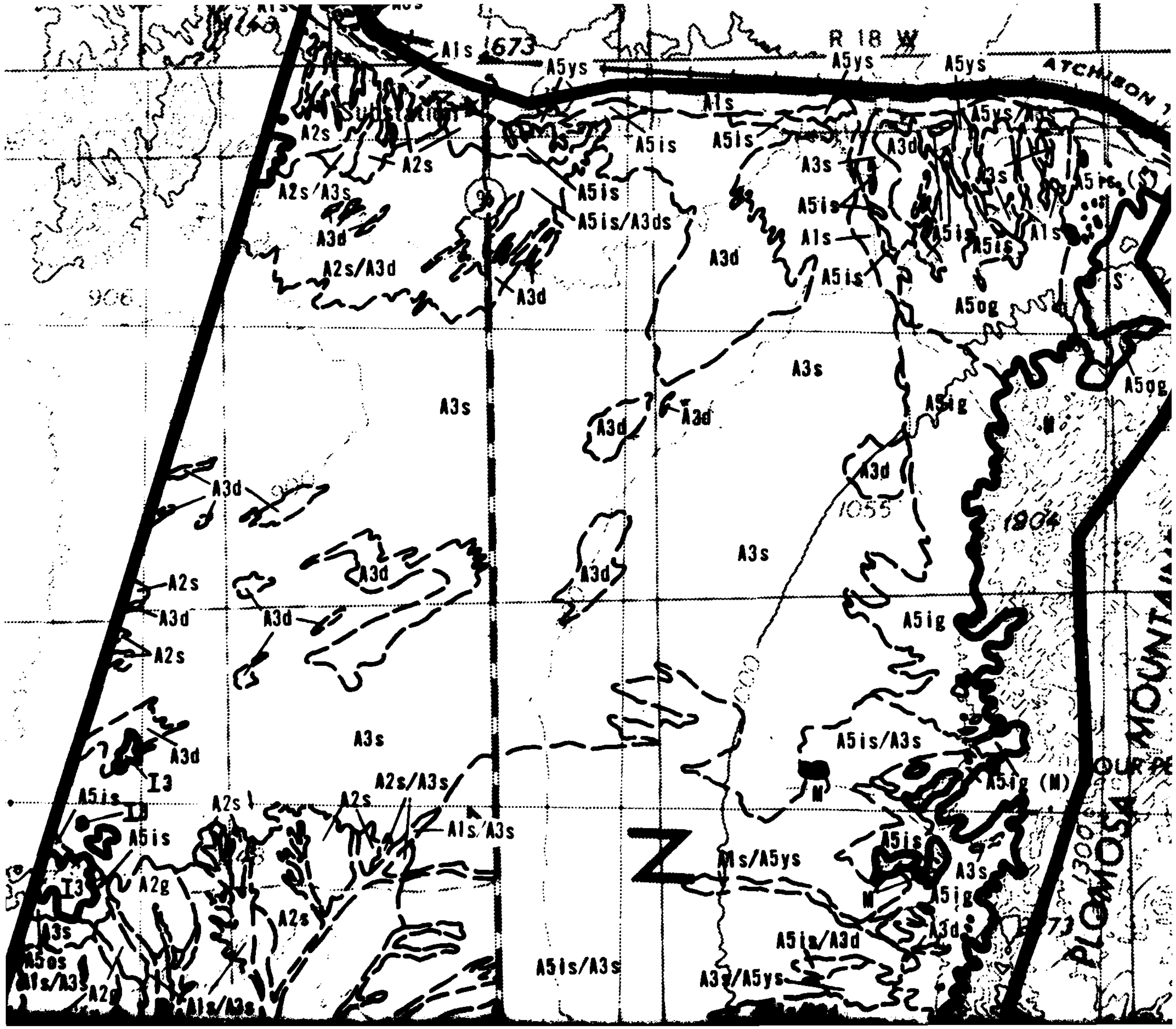
0 2 KILOMETERS

ACTIVITY LOCATIONS
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING 3-1

FUGRO NATIONAL, INC.



R 18 W
ATCHISON
PLOMOSA MOUNTAINS
Substation
A1s
A5ys
A2s
A2s/A3s
A3d
A2s/A3d
A5is
A5is/A3ds
A3s
A5is/A3s
A5ig
A5ig (M)
A5og
A5ys/A3s
A5is/A3d
A3s/A5ys
A1s/A5ys
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A2s/A3s
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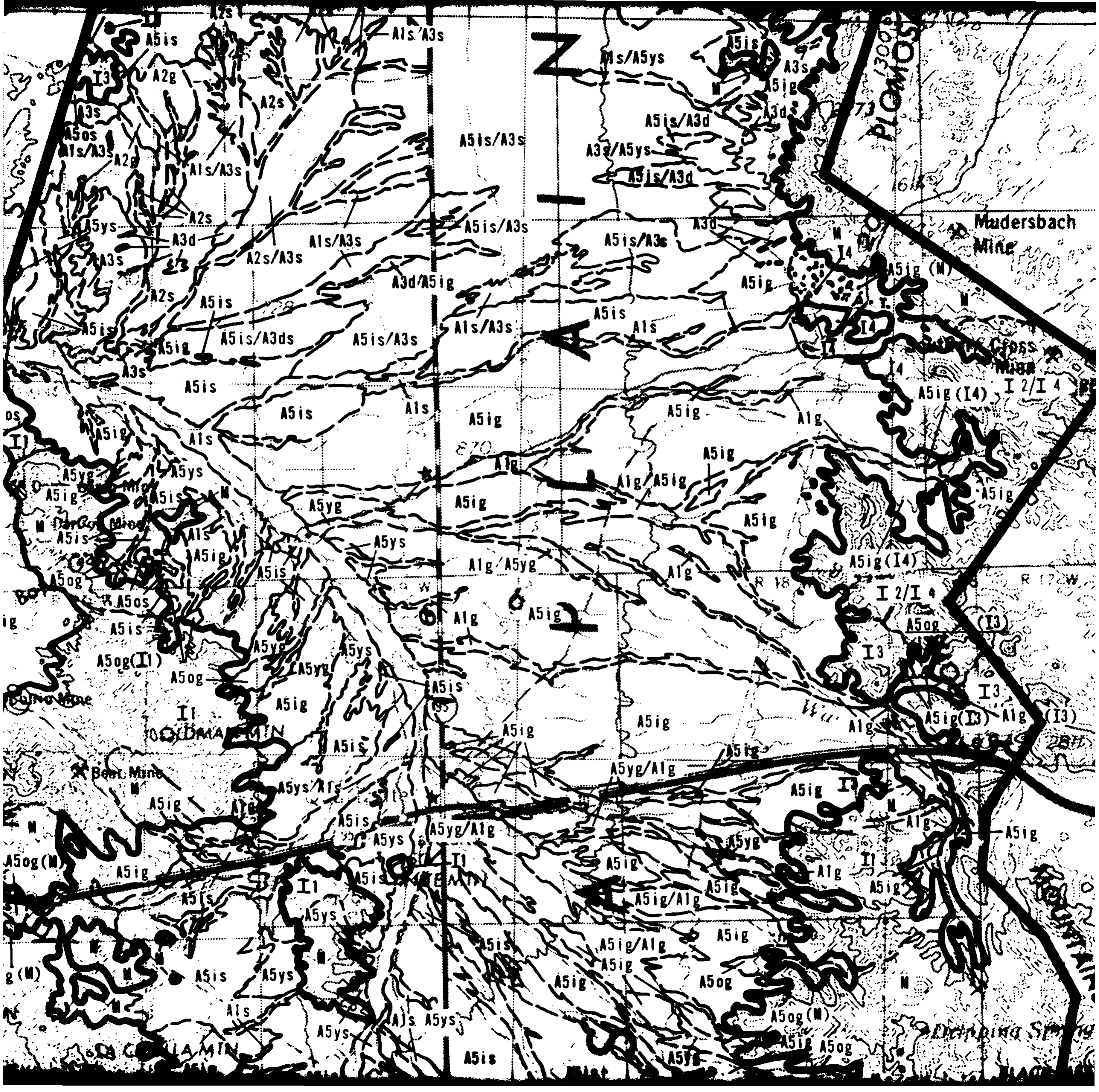
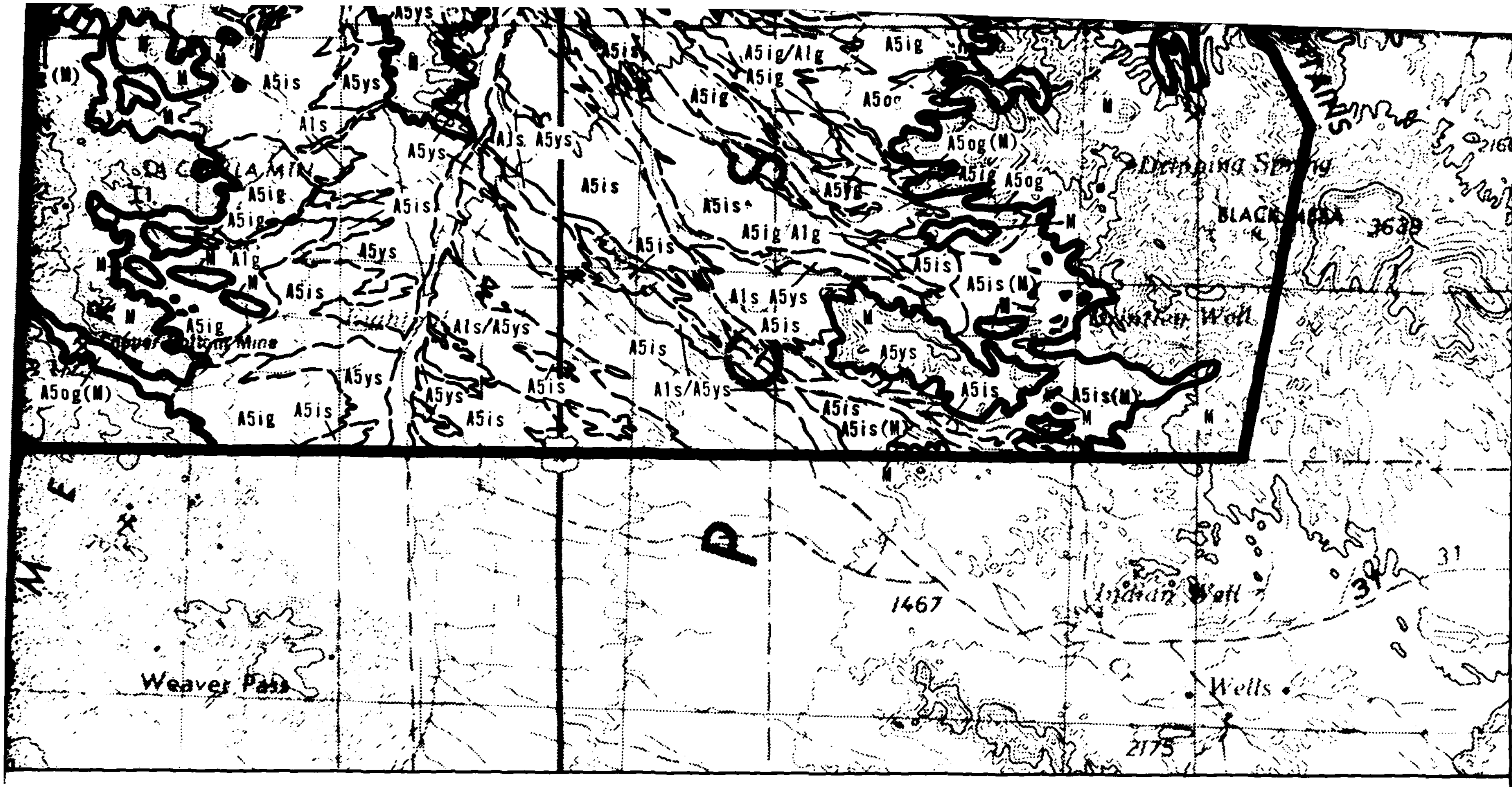
1055
1904
1300
906



Mudersbach
Mine
PLOMOSA
Cross
Mine
Bear Mine
Dripping Spring



EXPLANATION

SURFICIAL BASIN-FILL UNITS

A1s / A1g	Younger Fluvial Deposits - Modern stream channel and flood-plain deposits of: A1s, silty sand and gravelly sand (SM, SP) and A1g, sandy gravel (GP).
A2s / A2g	Older Fluvial Deposits - Older stream channel and flood-plain deposits of: A2s, uncemented and weakly cemented silty sand and gravelly sand (SM) and A2g, moderately cemented sandy gravel (GM).
A3s / A3d	Eolian Deposits - Windblown silty sand (SM) in: A3s, thin sheets and A3d, stabilized dunes.

... Alluvial Fan Deposits - Active, younger alluvial fan deposits of: A5ys, silty sand

A2g	and weakly cemented silty sand and gravelly sand (SM) and A2g, moderately cemented sandy gravel (GM).
A3s / A3d	Eolian Deposits - Windblown silty sand (SM) in: A3s, thin sheets and A3d, stabilized dunes.
A5ys / A5yg	Younger Alluvial Fan Deposits - Active, younger alluvial fan deposits of: A5ys, silty sand and gravelly sand (SM) and A5yg, sandy gravel (GM).
A5is / A5ig	Intermediate Alluvial Fan Deposits - Inactive intermediate-age alluvial fan deposits of: A5is, weakly cemented silty sand and gravelly sand (SM) and A5ig, weakly cemented sandy gravel (GM).
A5os / A5og	Older Alluvial Fan Deposits - Older, highly eroded alluvial fan deposits of: A5os, weakly cemented gravelly sand (SM) and A5og, weakly and moderately cemented sandy gravel (GP).

ROCK UNITS

Igneous (I)

I1	Granite, quartz monzonite, granodiorite, and quartz diorite
I2	Andesite with minor tuffaceous sedimentary rocks
I3	Basalt
I4	Andesitic tuff and breccia

Sedimentary (S)

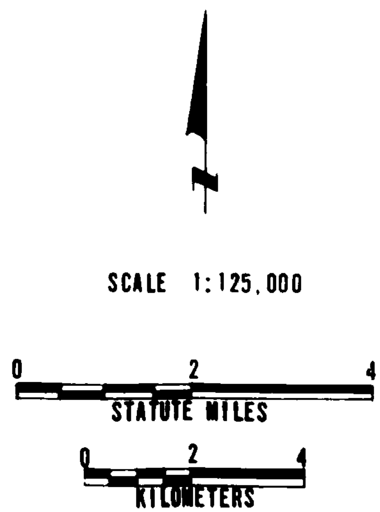
S	Undifferentiated shale, sandstone, conglomerate, and limestone

Metamorphic (M)

M	Gneiss and schist

A1g/A5ig Combination of geologic unit symbols indicates a mixture of either surficial basin-fill or rock units inseparable at map scale.

A5ys (I2) Parenthetic unit underlies surface unit at shallow depth.



SYMBOLS

Contact between rock and basin-fill.

Contact between surficial basin-fill or rock units.

NOTES: 1. Surficial basin-fill units pertain only to the upper several feet of soil. Due to variability of

ROCK UNITS

Igneous (I)

I1	Granite, quartz monzonite, granodiorite, and quartz diorite
I2	Andesite with minor tuffaceous sedimentary rocks
I3	Basalt
I4	Andesitic tuff and breccia

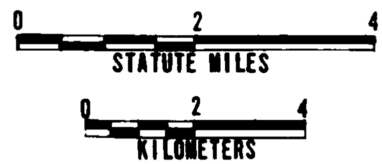
Sedimentary (S)

S	Undifferentiated shale, sandstone, conglomerate, and limestone

Metamorphic (M)

M	Gneiss and schist

SCALE 1:125,000



A1g/A5ig Combination of geologic unit symbols indicates a mixture of either surficial basin-fill or rock units inseparable at map scale.

A5ys (I2) Parenthetic unit underlies surface unit at shallow depth.

SYMBOLS

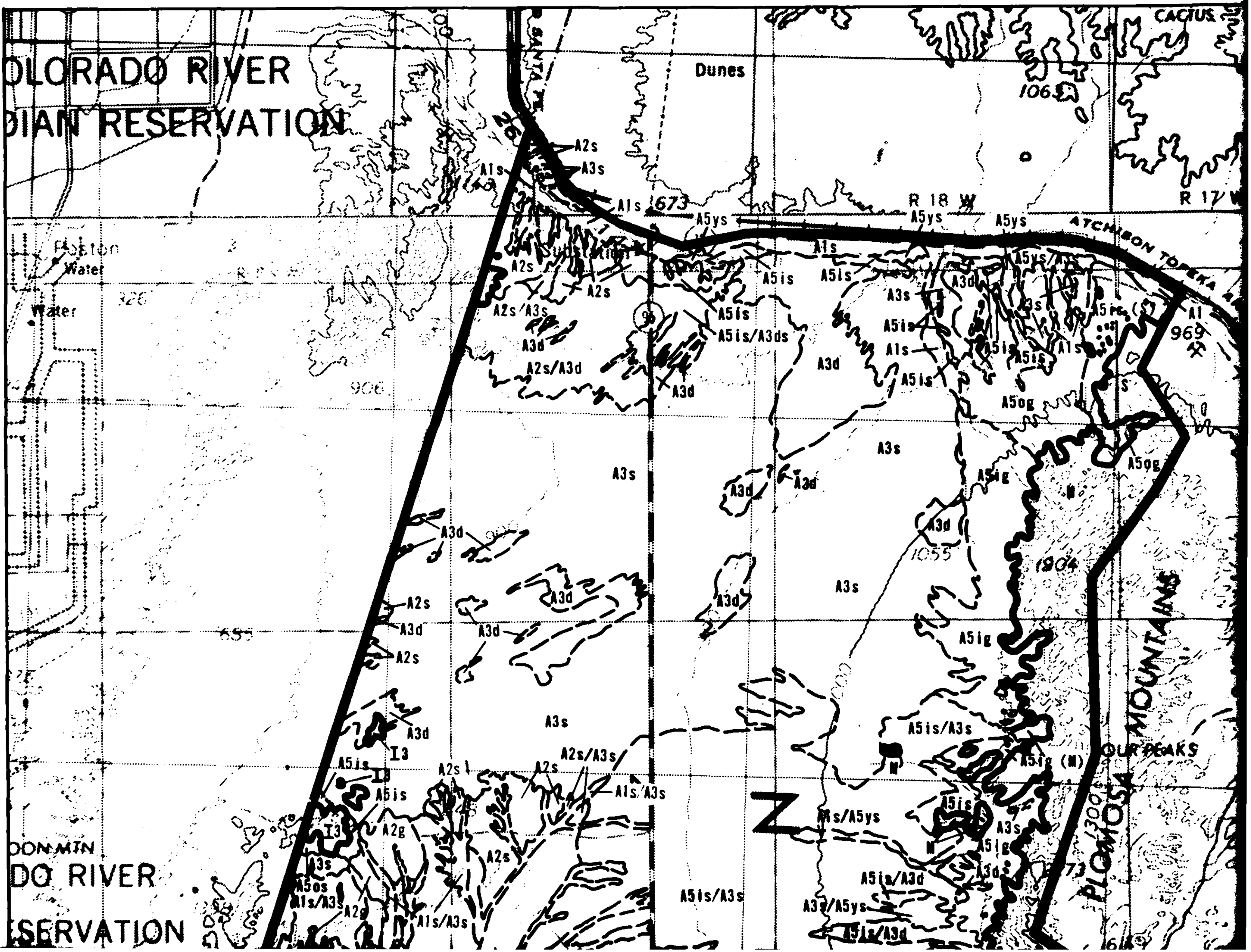
Contact between rock and basin-fill.

Contact between surficial basin-fill or rock units.

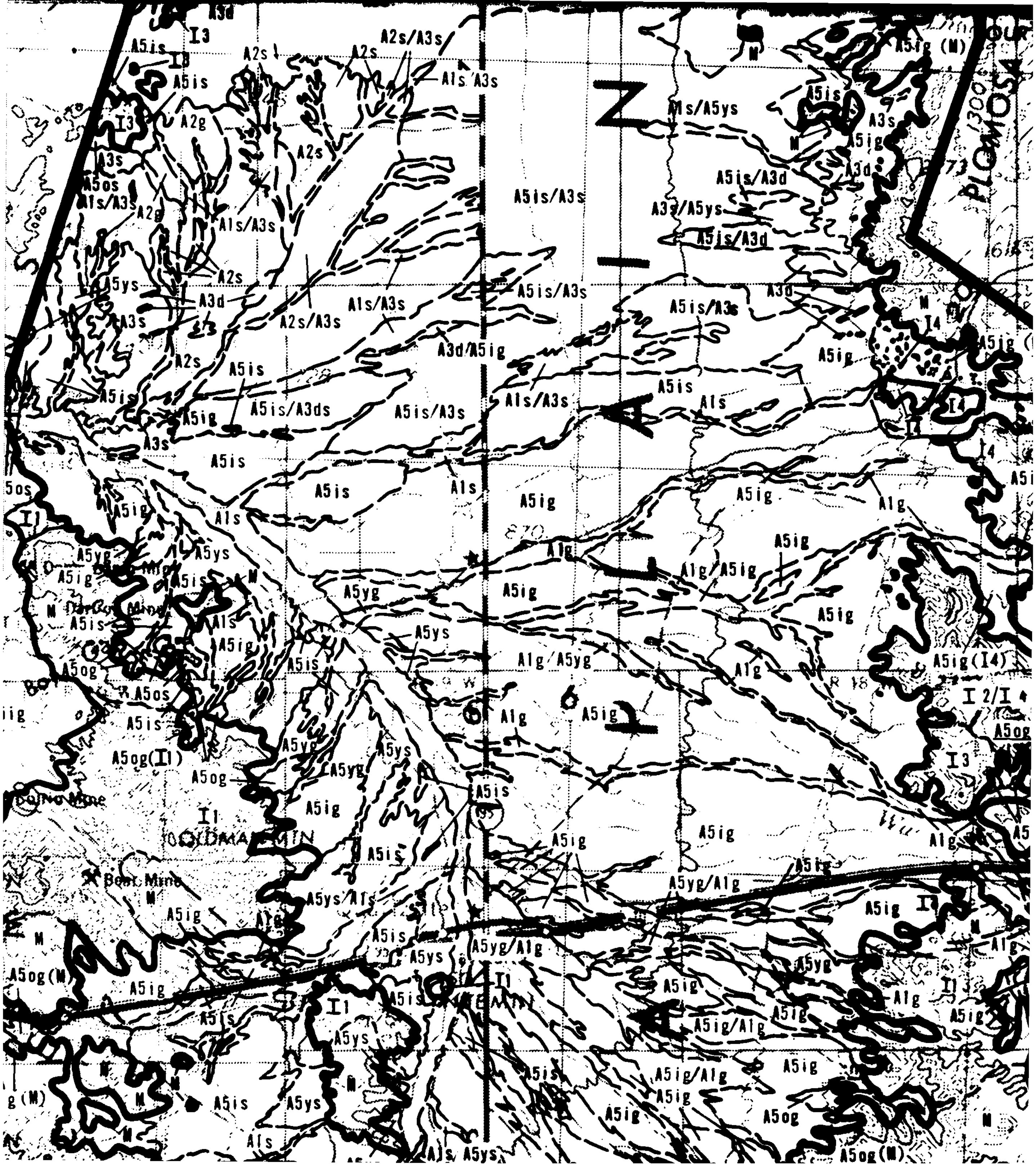
NOTES: 1. Surficial basin-fill units pertain only to the upper several feet of soil. Due to variability of surficial deposits and scale of map presentation, unit descriptions refer to the predominant soil types. Varying amounts of other soil types can be expected within each geologic unit.

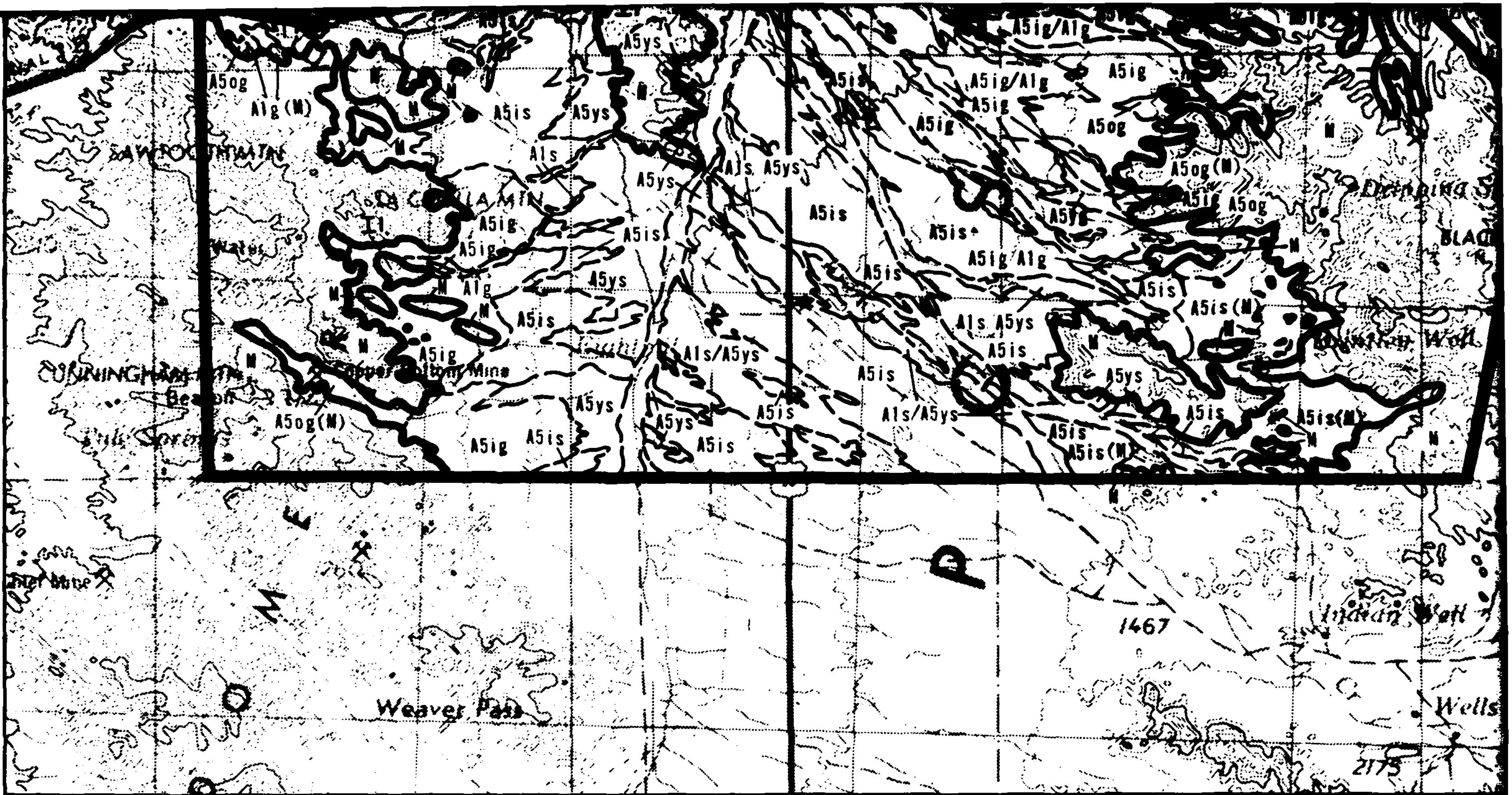
2. The distribution of geologic data stations is presented in Volume I Drawing 1. A tabulation of all station data and generalized description of all geologic units is included in Volume I Section 1 0.

3. Geology in areas of exposed rock from Jemmett (1966), Miller (1970), and Wilson et. al. (1969).


COLORADO RIVER
INDIAN RESERVATION
DO RIVER
SERVATION
Dunes
CACTUS
R 18 W
R 17 W
ATCHISON TOPEKA
SANTA FE
PLOMOSA
MOUNTAINS
FOUR PEAKS
Poston
Water
Water
1065
673
969
1904
1055
95
A1s
A2s
A3s
A3d
A5ys
A5is
A5is/A3ds
A2s/A3s
A2s/A3d
A5ys/A3s
A5og
A5ig
A5ig (M)
A5is/A3s
A5is/A3d
A1s/A3s
A2g
A5os
I3
A3s/A5ys
A1s/A5ys
Z
10 AUG 79

6


PLOMOSA
A5is/A3s
A5is/A3d
A5is/A3d
A5is/A3s
Als/A3s
A2s/A3s
Als/A3s
A2s/A3s
A3d/A5ig
A5is/A3ds
A5is/A3s
Alg/A5ig
Alg/A5yg
A5yg/Alg
A5ys/Als
A5ig/Alg
A5og(I1)
A5ig(I4)
A5is
A5ig
A5yg
A5ys
A5og
Alg
Als
A2s
A2g
A3d
A3s
I1
I3
I4
Bonanza Mine
Bear Mine



EXPLANATION

SURFICIAL BASIN-FILL UNITS

A1s / A1g	Younger Fluvial Deposits - Modern stream channel and flood-plain deposits of: A1s, silty sand and gravelly sand (SM, SP) and A1g, sandy gravel (GP).
A2s / A2g	Older Fluvial Deposits - Older stream channel and flood-plain deposits of: A2s, uncemented and weakly cemented silty sand and gravelly sand (SM) and A2g, moderately cemented sandy gravel (GM).
A3s / A3d	Eolian Deposits - Windblown silty sand (SM) in: A3s, thin sheets and A3d, stabilized dunes.

A2s / A2g	Older Fluvial Deposits - Older stream channel and flood-plain deposits of: A2s, uncemented and weakly cemented silty sand and gravelly sand (SM) and A2g, moderately cemented sandy gravel (GM).
A3s / A3d	Eolian Deposits - Windblown silty sand (SM) in: A3s, thin sheets and A3d, stabilized dunes.
A5ys / A5yg	Younger Alluvial Fan Deposits - Active, younger alluvial fan deposits of: A5ys, silty sand and gravelly sand (SM) and A5yg, sandy gravel (GM).
A5is / A5ig	Intermediate Alluvial Fan Deposits - Inactive intermediate-age alluvial fan deposits of: A5is, weakly cemented silty sand and gravelly sand (SM) and A5ig, weakly cemented sandy gravel (GM).
A5os / A5og	Older Alluvial Fan Deposits - Older, highly eroded alluvial fan deposits of: A5os, weakly cemented gravelly sand (SM) and A5og, weakly and moderately cemented sandy gravel (GP).

ROCK UNITS

Igneous (I)

I1	Granite, quartz monzonite, granodiorite, and quartz diorite
I2	Andesite with minor tuffaceous sedimentary rocks
I3	Basalt
I4	Andesitic tuff and breccia

Sedimentary (S)

S	Undifferentiated shale, sandstone, conglomerate, and limestone

Metamorphic (M)

M	Gneiss and schist

A1g/A5ig Combination of geologic unit symbols indicates a mixture of either surficial basin-fill or rock units inseparable at map scale.

A5ys (I2) Parenthetic unit underlies surface unit at shallow depth.

SYMBOLS

Contact between rock and basin-fill.

Contact between surficial basin-fill or rock units.

SCALE 1:

0 2

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0 2

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DEPARTMENT OF

FUGRO

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A5os A5og	**Older Alluvial Fan Deposits** - Older, highly eroded alluvial fan deposits of: A5os, weakly cemented gravelly sand (SM) and A5og, weakly and moderately cemented sandy gravel (GP).

ROCK UNITS

Igneous (I)

I1	Granite, quartz monzonite, granodiorite, and quartz diorite
I2	Andesite with minor tuffaceous sedimentary rocks
I3	Basalt
I4	Andesitic tuff and breccia

Sedimentary (S)

S	Undifferentiated shale, sandstone, conglomerate, and limestone

Metamorphic (M)

M	Gneiss and schist

A1g/A5ig Combination of geologic unit symbols indicates a mixture of either surficial basin-fill or rock units inseparable at map scale.

A5ys (I2) Parenthetic unit underlies surface unit at shallow depth.

SYMBOLS

Contact between rock and basin-fill.

Contact between surficial basin-fill or rock units.

NOTES: 1. Surficial basin-fill units pertain only to the upper several feet of soil. Due to variability of surficial deposits and scale of map presentation, unit descriptions refer to the predominant soil types. Varying amounts of other soil types can be expected within each geologic unit.

2 The distribution of geologic data stations is presented in Volume I Drawing 1. A tabulation of all station data and generalized descriptión of all geologic units is included in Volume I Section 1 0

3. Geology in areas of exposed rock from Jemmett (1966), Miller (1970), and Wilson et. al. (1969).

SCALE 1:12

0 2 STATUTE MI

0 2 KILOMETE

SURFICIAL GEOLOGIC UNITS
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING 3-2

FUGRO NATIONAL, INC.

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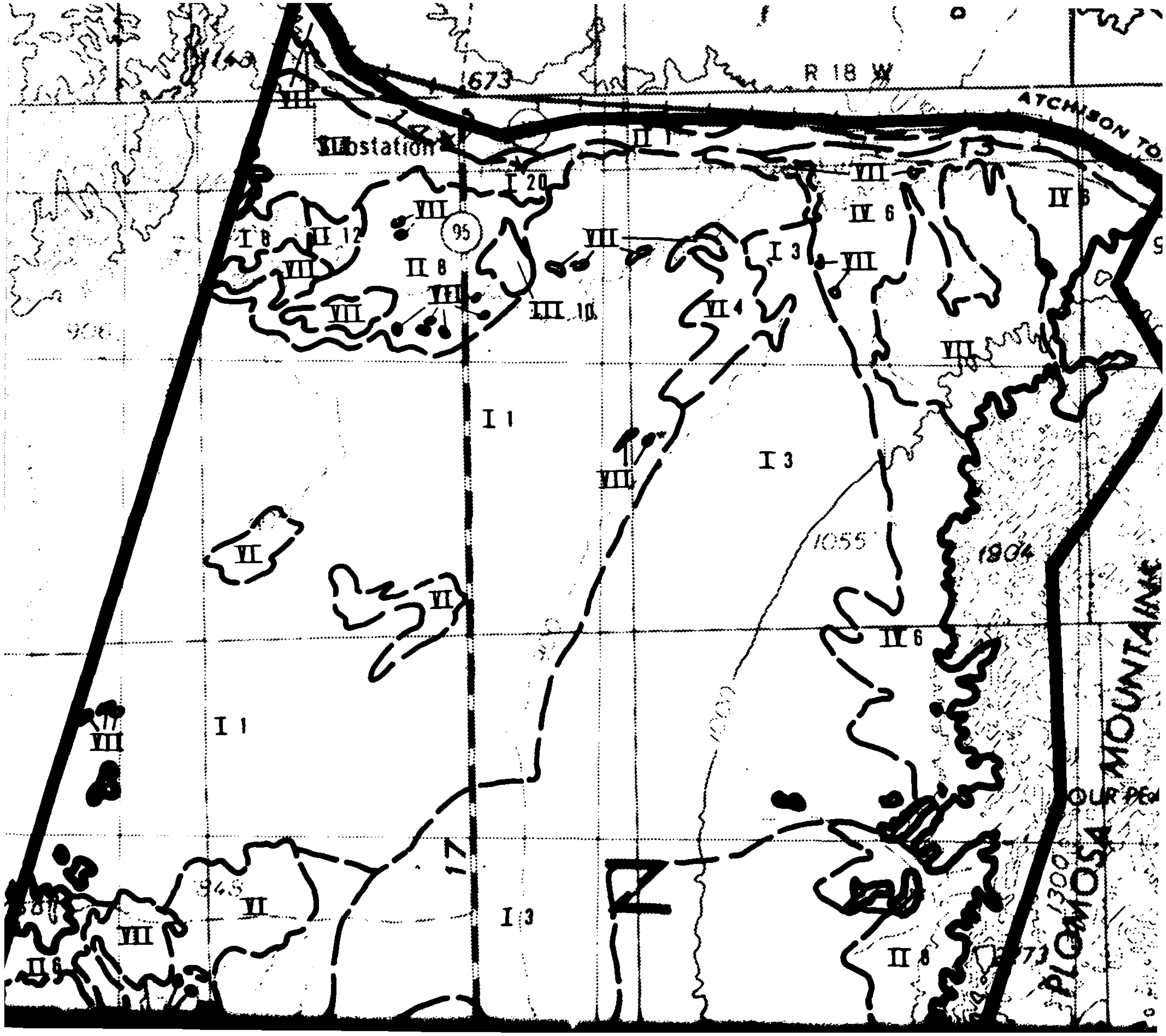
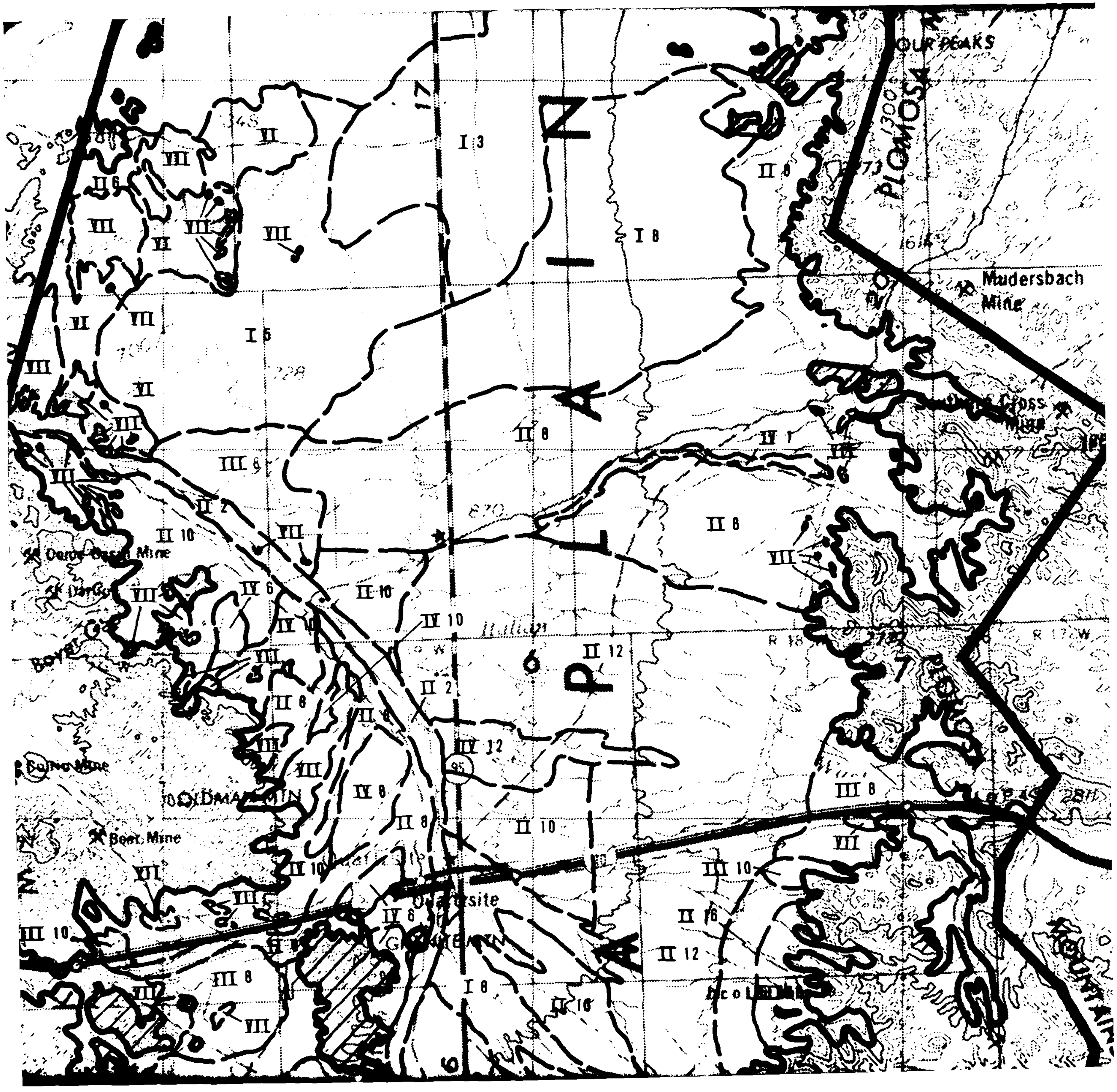
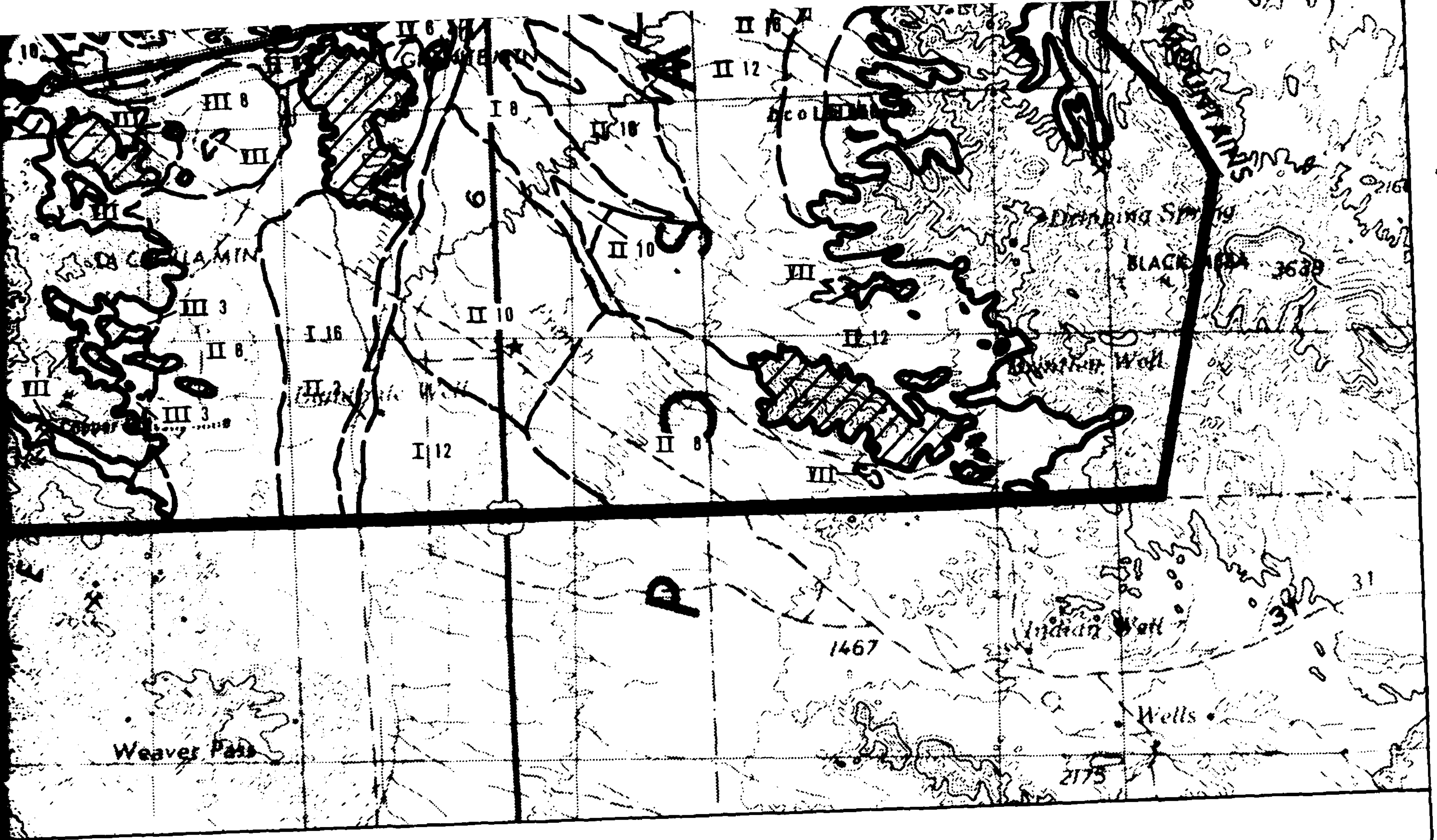
10



R 18 W
ATCHISON TO
673
Substation
95
17
1055
1904
PLOMOSA MOUNTAINS
1300



PLOMOSA
Mudersbach Mine
Boat Mine



EXPLANATION

Terrain Category ——— III 3 ——— Drainage spacing, i.e. the maximum number of drainages of the corresponding category occurring in a random traverse of one statute mile (1.6 km)
(See table below)

EXPLANATION

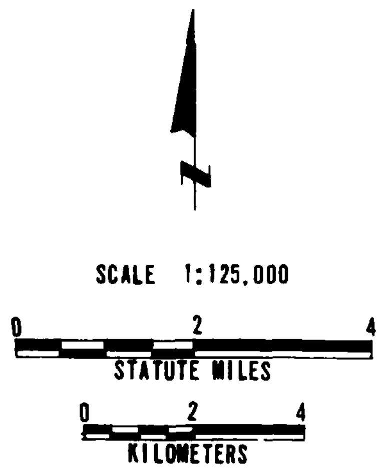
Terrain Category — — — — — III 3 — — — — — Drainage spacing, i.e. the maximum number of drainages of the corresponding category occurring in a random traverse of one statute mile (1.6 km)
(See table below)

TERRAIN CATEGORY	DRAINAGE DEPTH DESCRIPTION
I	Less than 3 feet (1m)
II	3-6 feet (1-2m)
III	6-10 feet (2-3m)
IV	10-15 feet (3-5m)
V	Greater than 15 feet (5m)
VI	Complex, highly variable terrain not defined by drainage incision (e.g. dunal or hummocky terrains).
VII	Unsuitable terrain (see Appendix A2.0, Exclusion Criteria)

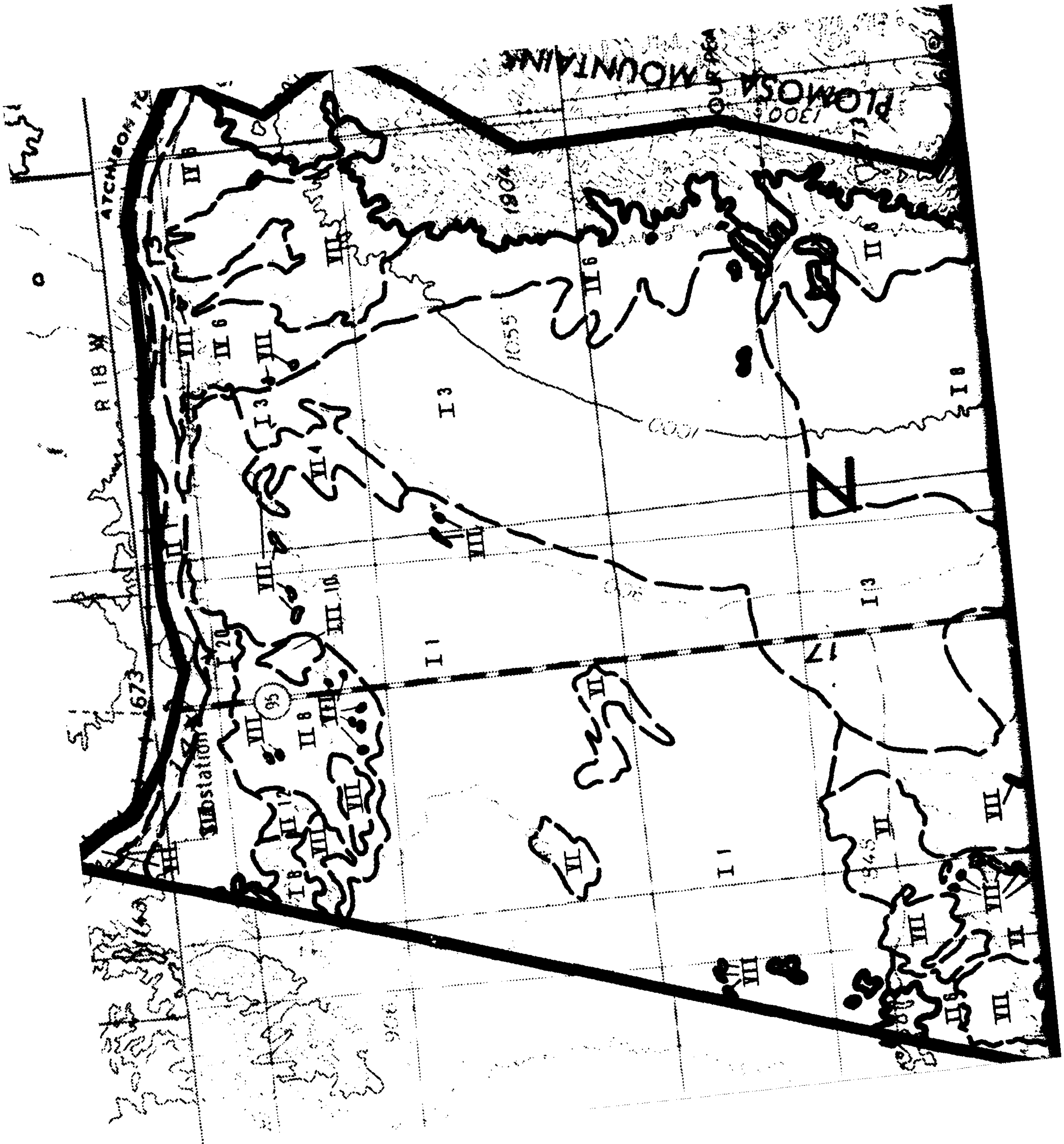
Contact between terrain categories

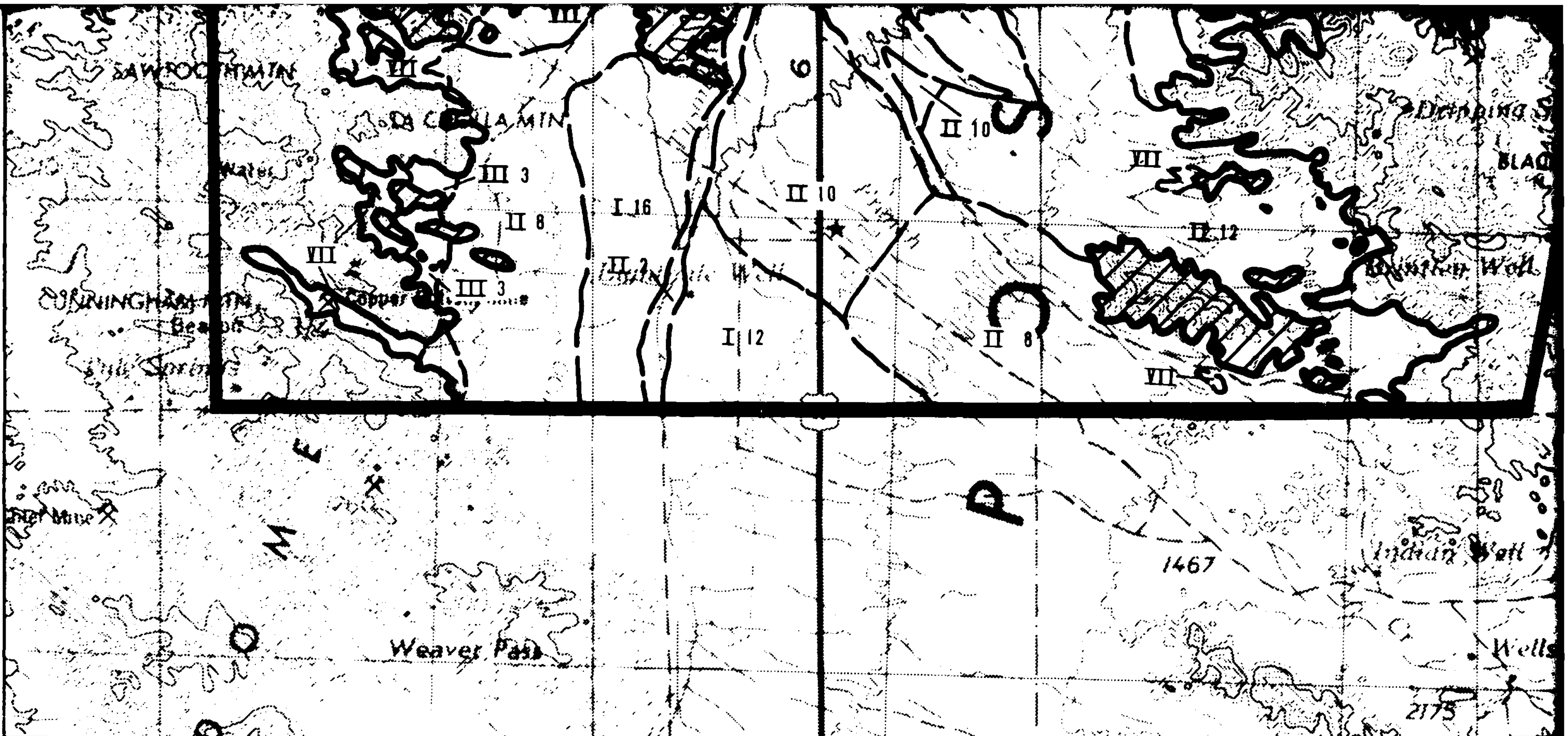
Contact between rock and basin-fill

Shading indicates areas of isolated exposed rock



NOTE: Data used in constructing this map are from: (1) field observations (2) 1:62,500 USGS topographic maps and (3) 1:62,500 and 1:25,000 aerial photographs. Due to scale of presentation and variability of terrain conditions, this map is generalized.


PLOMOSA MOUNTAINS
R 18 W
Substation
1673
1904
1055
1000
1300
95
17
Z



EXPLANATION

Terrain Category (See table below) — — — III 3 — — — Drainage spacing, i.e. the maximum number of drainages of the corresponding category occurring in a random traverse of one statute mile (1.6 km)

TERRAIN CATEGORY	DRAINAGE DEPTH DESCRIPTION
I	Less than 3 feet (1m)
II	3-6 feet (1-2m)
[illegible]	[illegible]

EXPLANATION

Terrain Category (See table below) — III 3 — Drainage spacing, i.e. the maximum number of drainages of the corresponding category occurring in a random traverse of one statute mile (1.6 km)

TERRAIN CATEGORY	DRAINAGE DEPTH DESCRIPTION
I	Less than 3 feet (1m)
II	3-6 feet (1-2m)
III	6-10 feet (2-3m)
IV	10-15 feet (3-5m)
V	Greater than 15 feet (5m)
VI	Complex, highly variable terrain not defined by drainage incision (e.g. dunal or hummocky terrains).
VII	Unsuitable terrain (see Appendix A2.0, Exclusion Criteria)

Contact between terrain categories

Contact between rock and basin-fill

Shading indicates areas of isolated exposed rock

NOTE: Data used in constructing this map are from: (1) field observations (2) 1:62 500 USGS topographic maps and (3) 1:62,500 and 1:25,000 aerial photographs. Due to scale of presentation and variability of terrain conditions, this map is generalized.

SCALE 1:125,000

0 2 STATUTE MILES

0 2 KILOMETERS

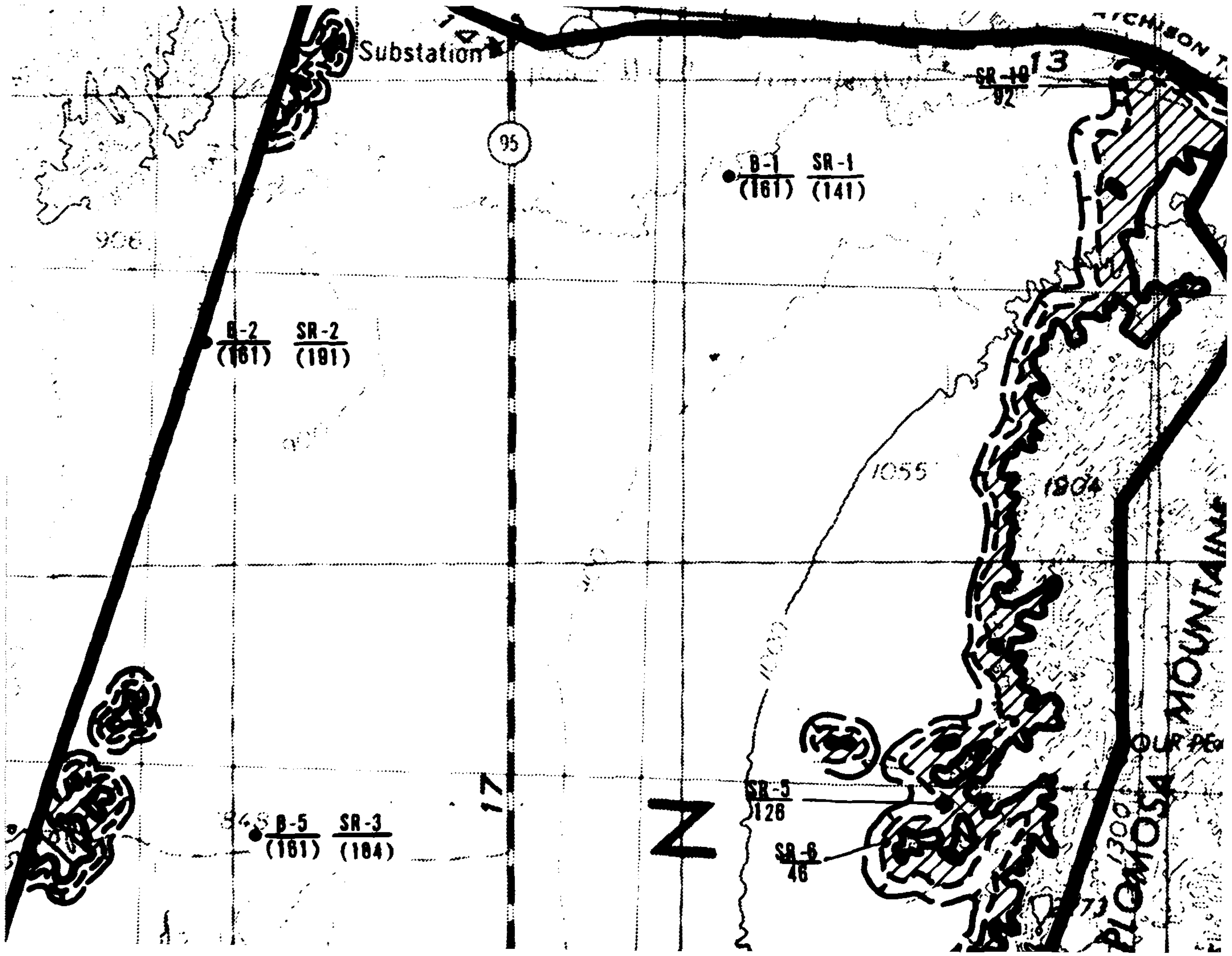
TERRAIN
VERIFICATION SITE, LA POSA COP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

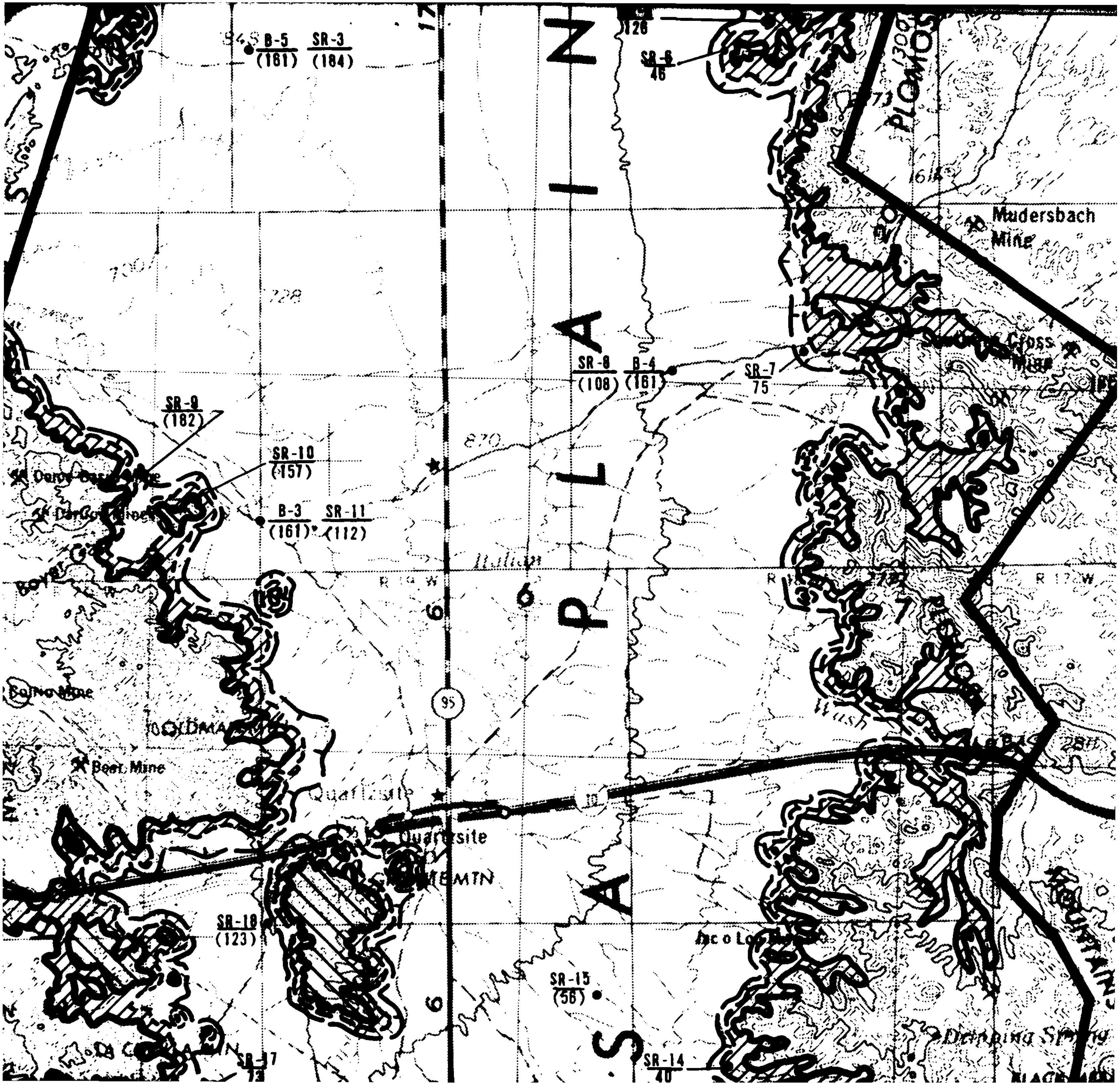
DRAWING 3-3

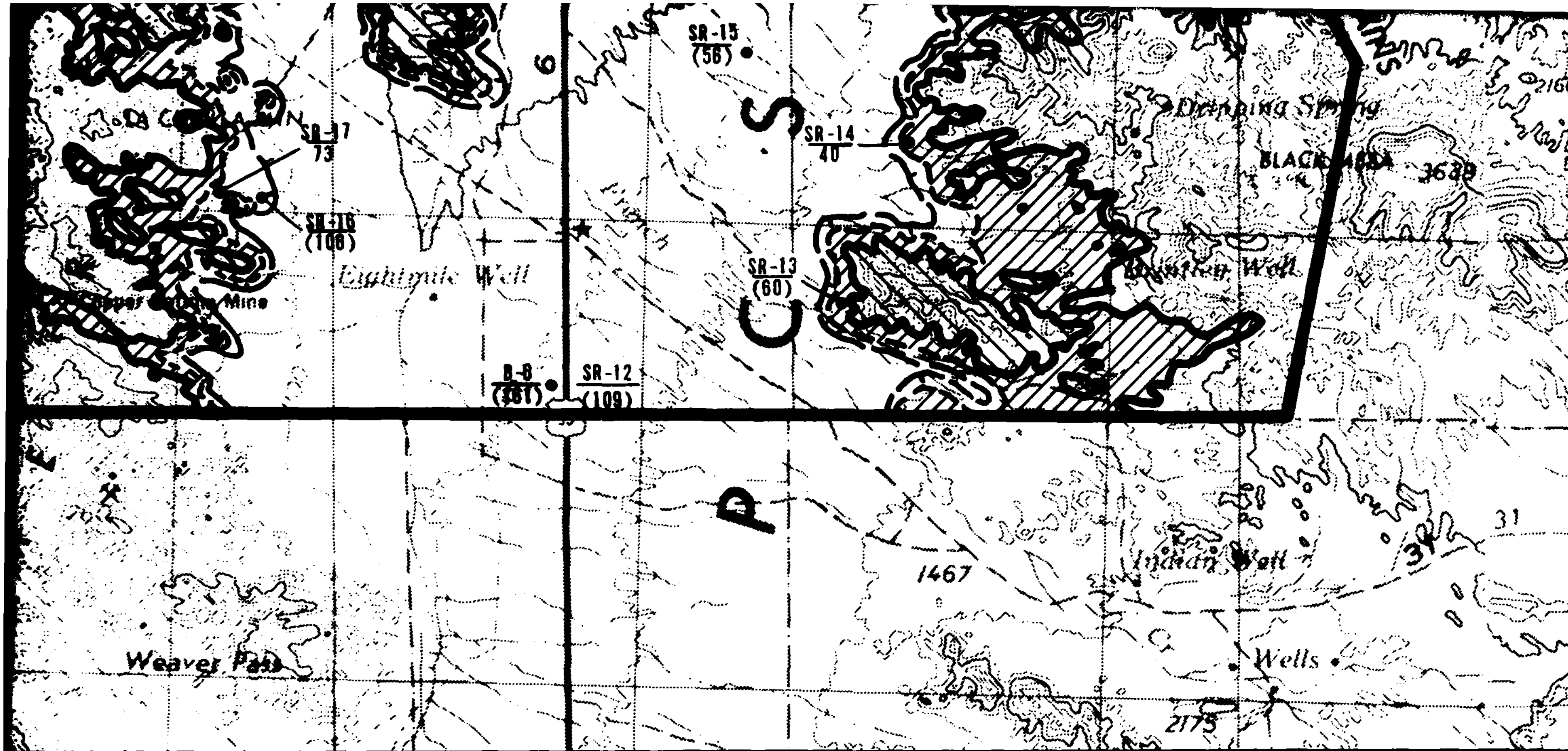
FUGRO NATIONAL, INC.

8



Substation
95
B-1 (161)
SR-1 (141)
SR-10 92
13
B-2 (161)
SR-2 (191)
906
1055
1904
MOUNTAINS
PLOMOSA
1300
17
Z
SR-5 126
SR-6 46
B-5 (161)
SR-3 (184)


B-5 (161)
SR-3 (184)
SR-6 46
PLOMOSA
Mudersbach Mine
Cross Mine
SR-8 (108)
B-4 (161)
SR-7 75
SR-9 (182)
SR-10 (157)
B-3 (161)
SR-11 (112)
PLAINS
95
Quartzsite
Bear Mine
SR-16 (123)
SR-15 (56)
SR-14 40
SR-17 13
R 19 W
R 17 W
Wash

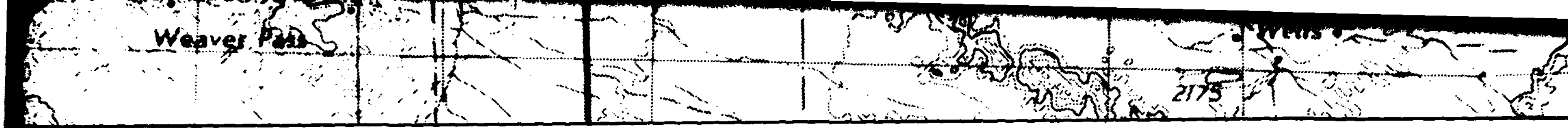


EXPLANATION

Contour indicates rock at a depth of approximately 50 feet (15m) - shading indicates rock less than 50 feet (15m).

Contour indicates rock at a depth of approximately 150 feet (46m) - hachuring indicates rock less than 150 feet (46m)

Contact between rock and basin-fill.



EXPLANATION

50 — Contour indicates rock at a depth of approximately 50 feet (15m) - shading indicates rock less than 50 feet (15m).

150 — Contour indicates rock at a depth of approximately 150 feet (46m) - hachuring indicates rock less than 150 feet (46m)

Contact between rock and basin-fill.

Shading indicates areas of isolated exposed rock.

$\frac{S4}{15}$ Data Source - Fugro boring (B), seismic refraction line (S), electrical resistivity sounding (R), or water well (W).
Depth to rock (feet) or, when in parentheses, depth above which rock does not occur (feet).

NOTE: The contours are based on geologic interpretations and the limited data points shown on the map. Some changes in contour locations can be expected as additional data are obtained.

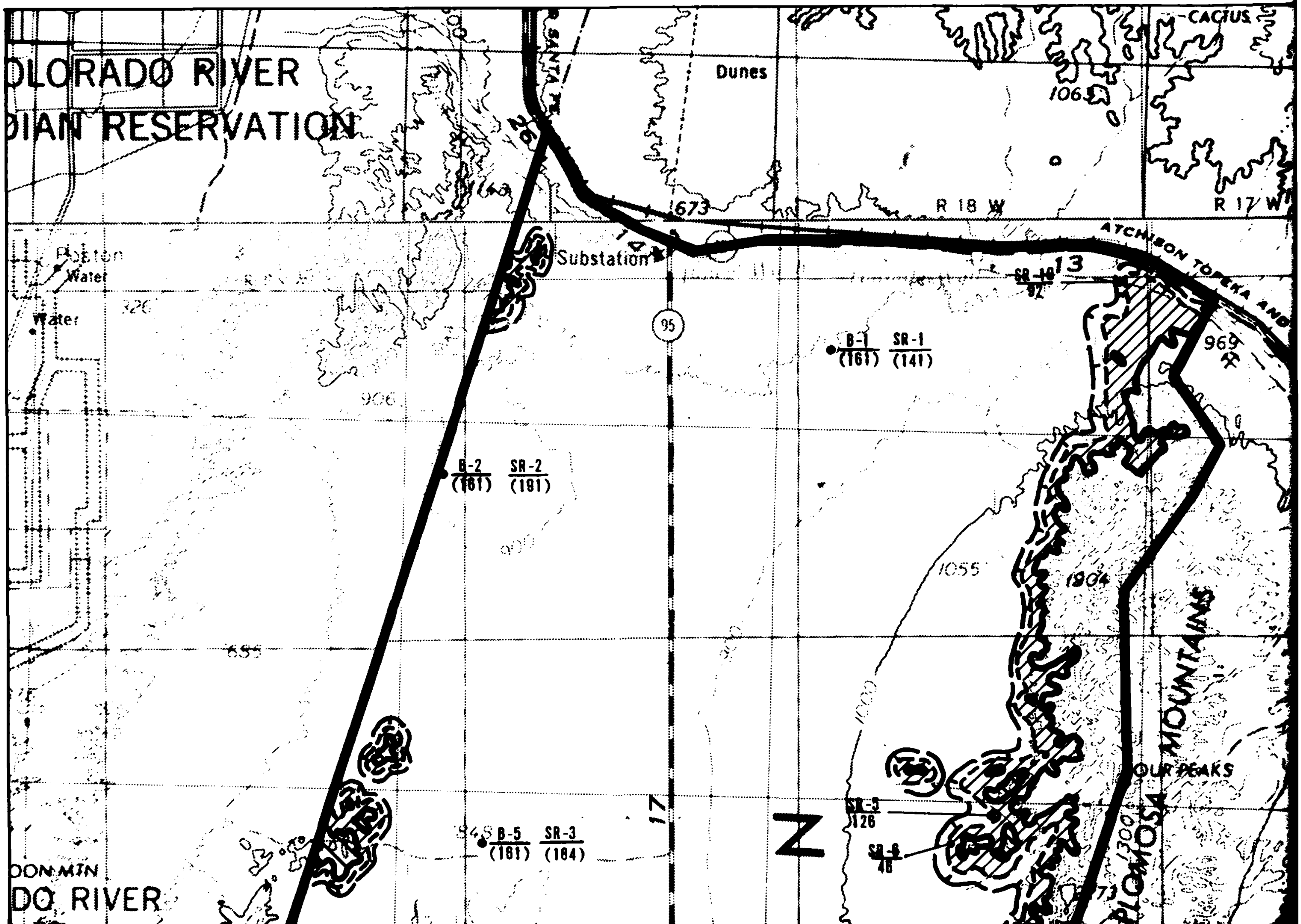
SCALE 1:125,000

0 2 4
STATUTE MILES

0 2 4
KILOMETERS

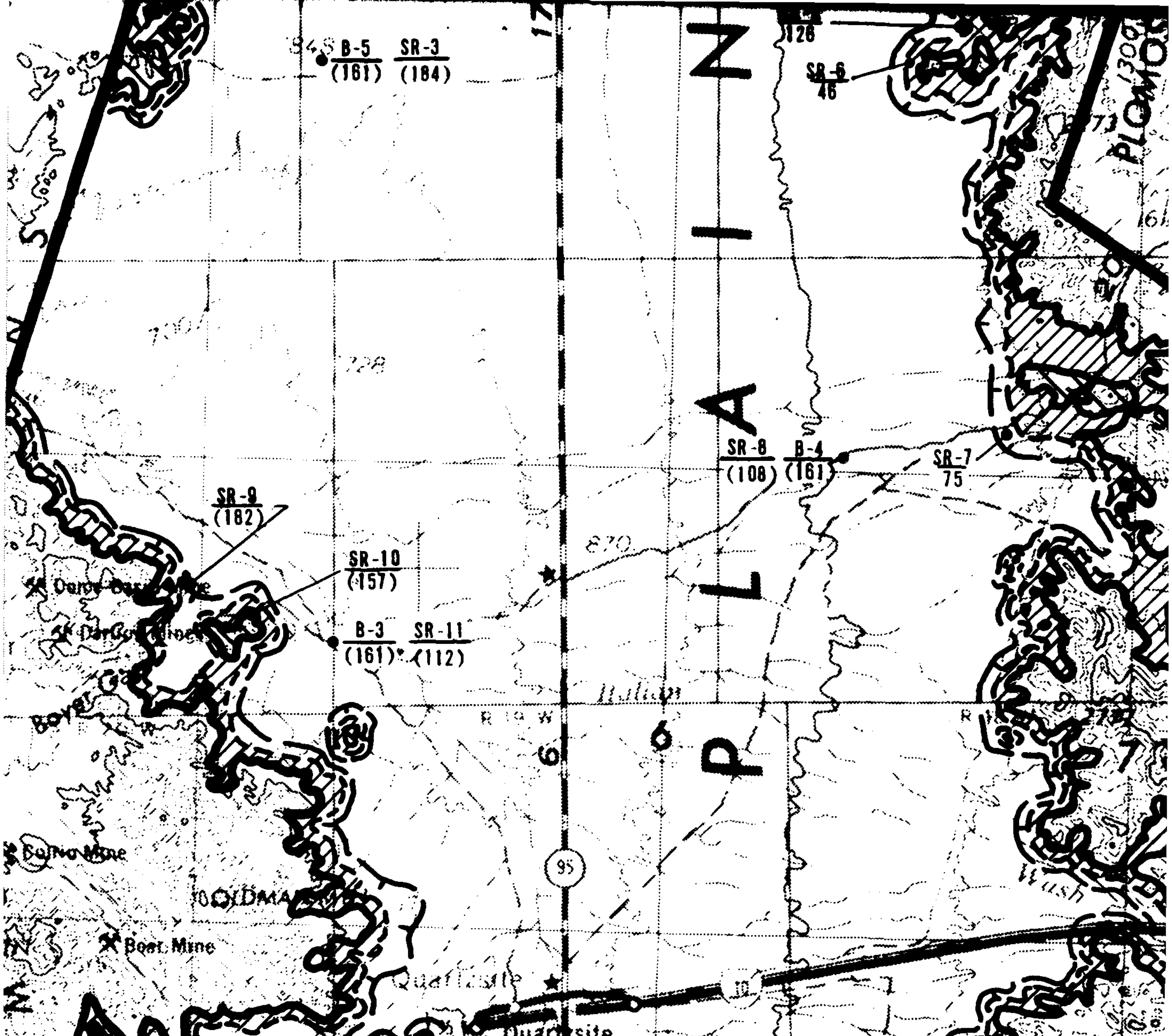
1

4

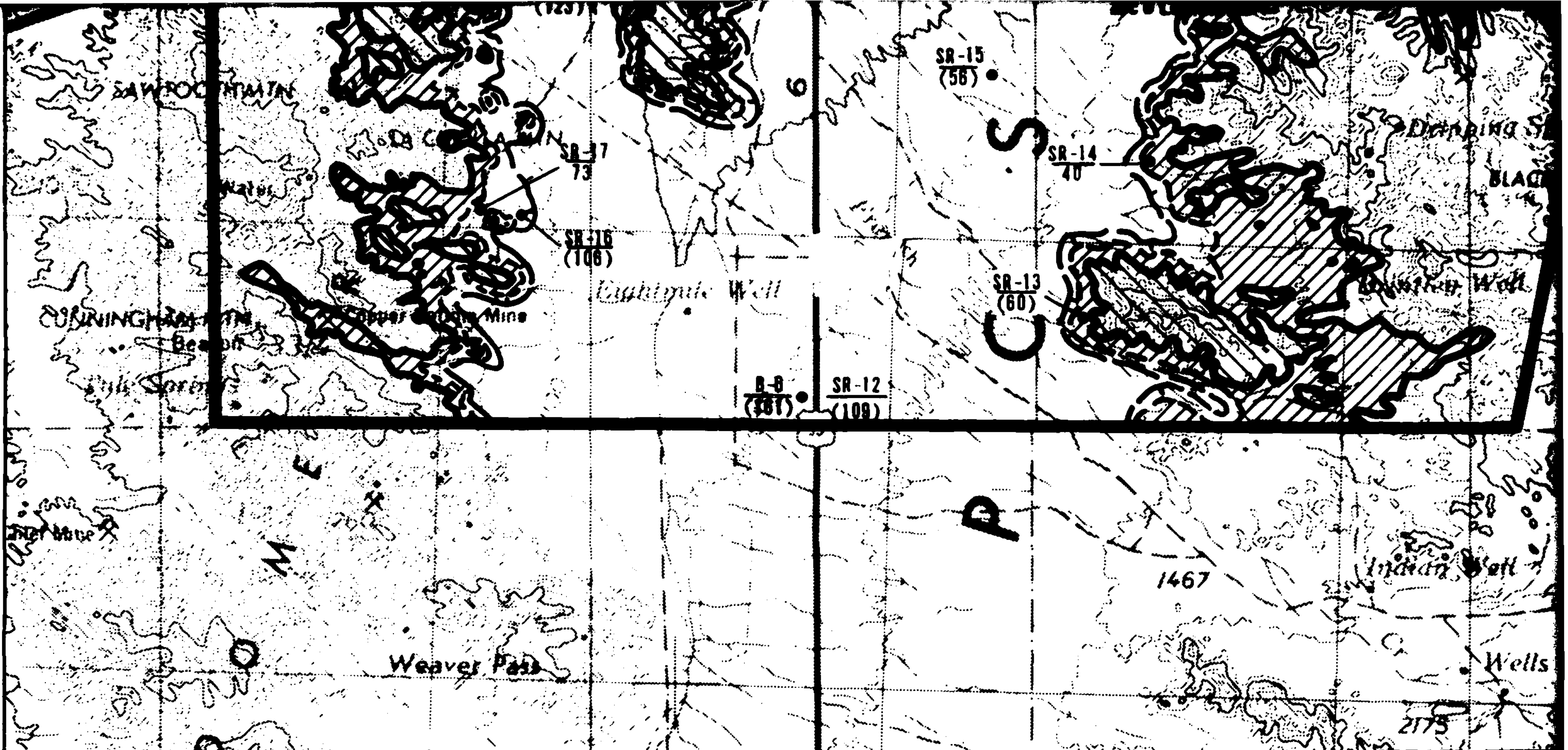

OLORADO RIVER
DIAN RESERVATION
Dunes
CACTUS
1063
R 18 W
R 17 W
673
26
SANTA FE
ATCHISON TOPEKA AND
Substation
13
14
95
969
B-1 (161)
SR-1 (141)
SR-10 92
B-2 (161)
SR-2 (181)
B-5 (161)
SR-3 (184)
SR-3 126
SR-6 46
906
1055
1904
1300
MOUNTAINS
OUR PEAKS
PLOMOSA
Z
17
Water
Water
OON MTN
DO RIVER

10 AUG 79

5



B-5 (161)
SR-3 (184)
SR-6 46
PLOMOS
SR-8 (108)
B-4 (161)
SR-7 75
SR-9 (182)
SR-10 (157)
B-3 (161)
SR-11 (112)
P L A I N
Bear Mine
Quartzsite
SR-18 (123)
SR-15 (56)
SR-17 73
SR-14 40
95
10



EXPLANATION

50 — Contour indicates rock at a depth of approximately 50 feet (15m) - shading indicates rock less than 50 feet (15m).

150 — Contour indicates rock at a depth of approximately 150 feet (46m) - hachuring indicates rock less than 150 feet (46m)

Contact between rock and basin-fill.

EXPLANATION

Contour indicates rock at a depth of approximately 50 feet (15m) - shading indicates rock less than 50 feet (15m).

150 Contour indicates rock at a depth of approximately 150 feet (46m) - hachuring indicates rock less than 150 feet (46m)

Contact between rock and basin-fill.

Shading indicates areas of isolated exposed rock.

S4/75 Data Source - Fugro boring (B), seismic refraction line (S), electrical resistivity sounding (R), or water well (W).

Depth to rock (feet) or, when in parentheses, depth above which rock does not occur (feet).

NOTE: The contours are based on geologic interpretations and the limited data points shown on the map. Some changes in contour locations can be expected as additional data are obtained.

SCALE 1:125,000

0 2 STATUTE MILES

0 2 4 KILOMETERS

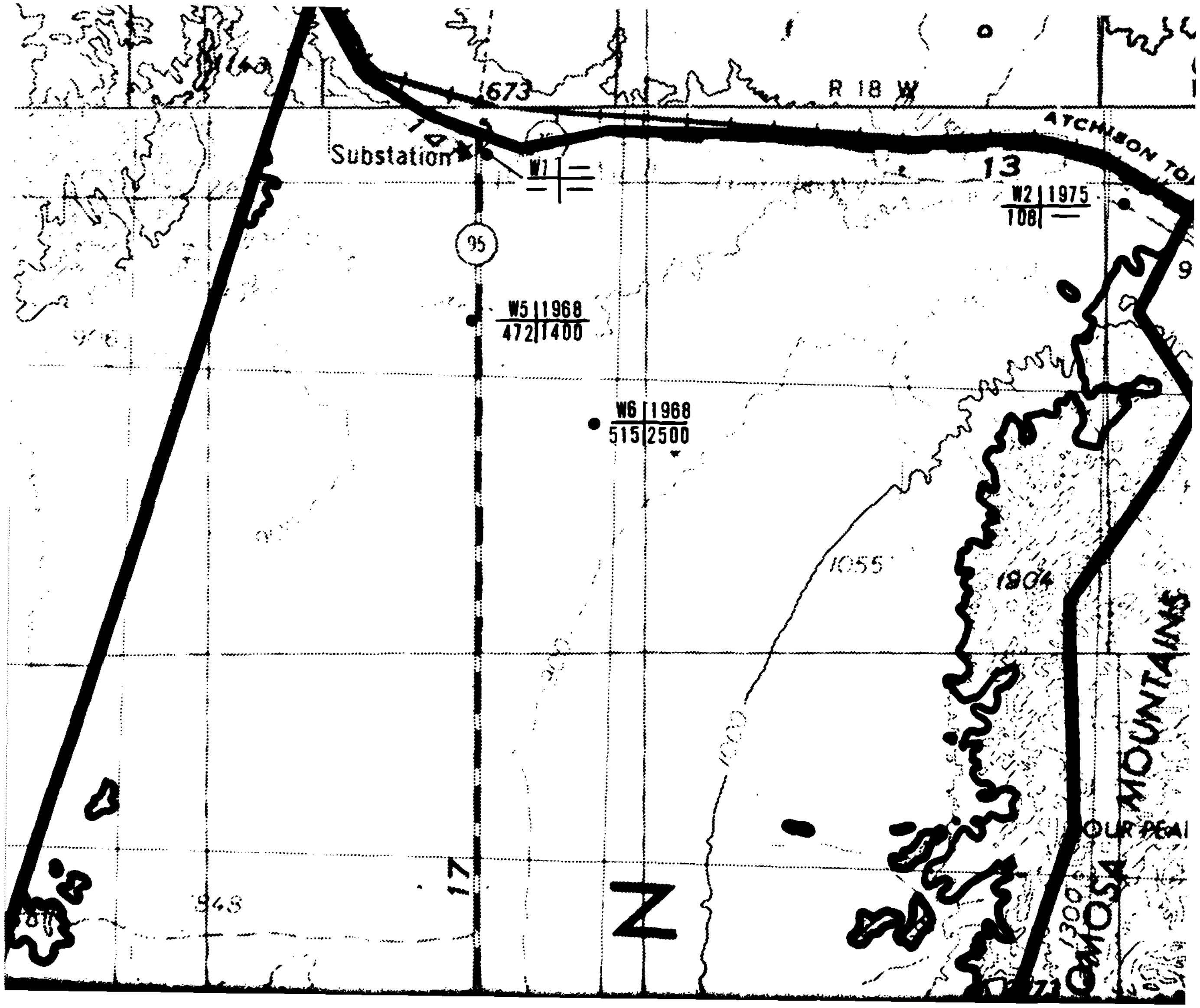
DEPTH TO ROCK
VERIFICATION SITE, LA POSA COP, ARIZONA

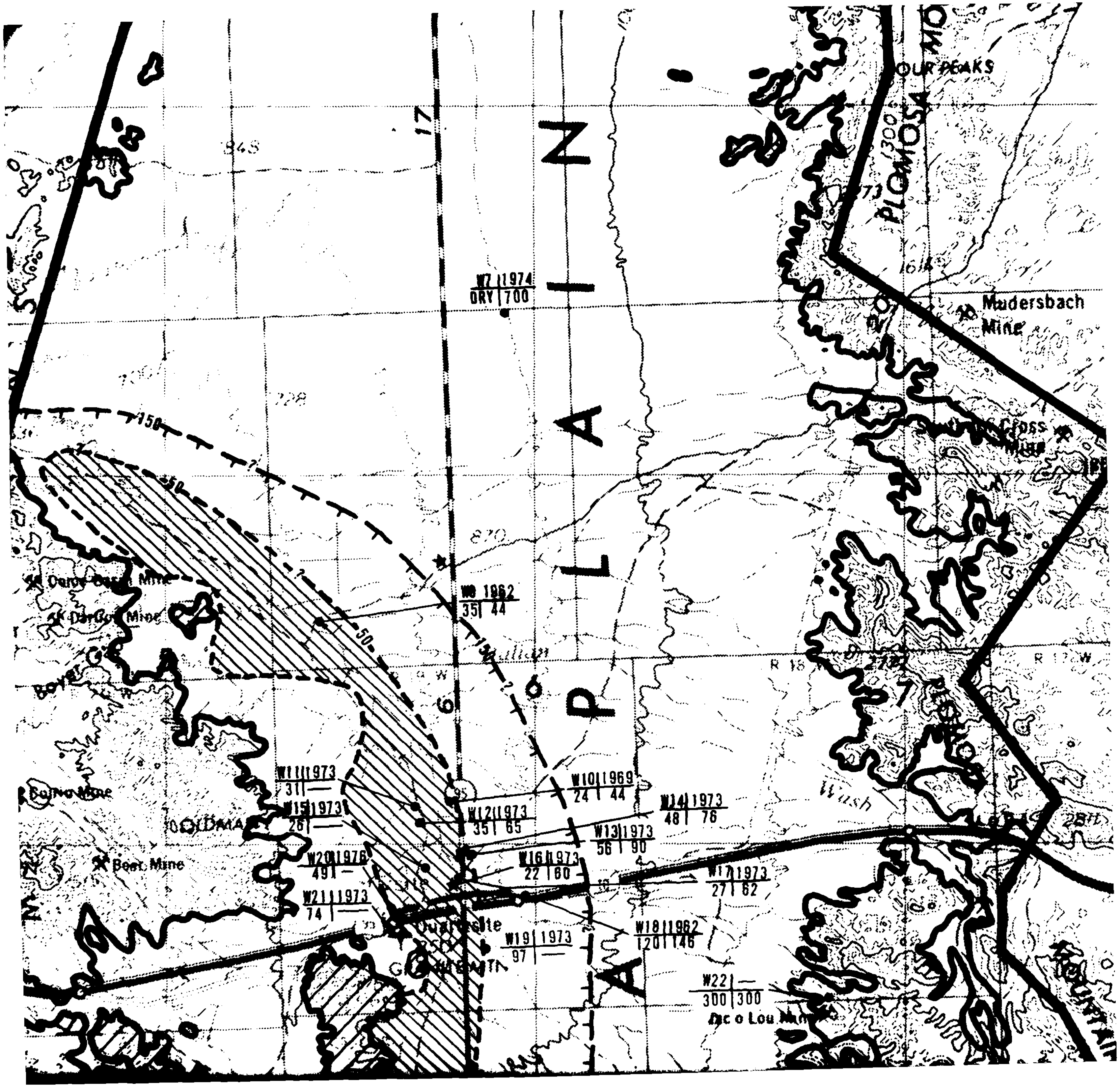
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

DRAWING 3-4

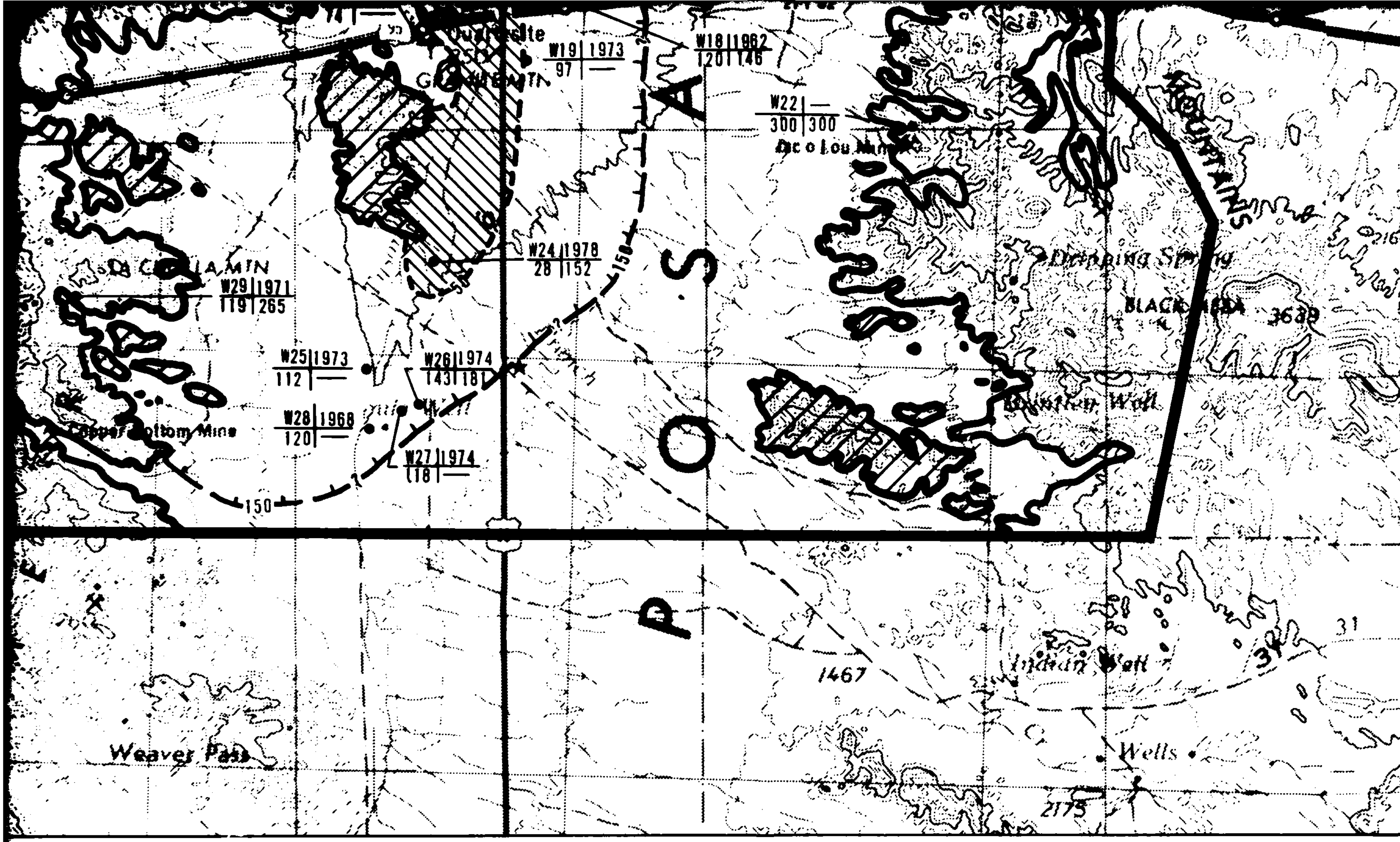
FUGRO NATIONAL, INC.

7 1 8


R 18 W
673
Substation
W1
W2 1975
108
13
95
W5 1968
472 1400
W6 1968
515 2500
1055
1904
17
945
MOUNTAINS
1300

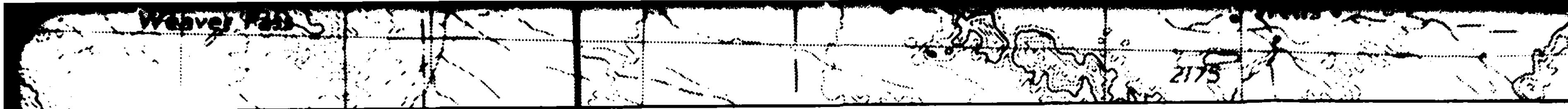


PLOMOSA
FOUR PEAKS
Mudersbach Mine
Southern Cross Mine
P L A I N
W7 1974
DRY 700
W8 1962
35 44
W10 1969
24 44
W11 1973
31
W12 1973
35 65
W13 1973
56 90
W14 1973
48 76
W15 1973
26
W16 1973
22 60
W17 1973
27 62
W18 1962
120 146
W19 1973
97
W20 1976
49
W21 1973
74
W22
300 300
Dome Rock Mine
Bear Mine
Quartzsite
Wash
R 18 W
R 17 W
R 19 W
150
50
17



EXPLANATION

50 Contour indicates ground water at a depth of approximately 50 feet (15m). Shading indicates less than 50 feet (15m) to ground water.



EXPLANATION

50 — Contour indicates ground water at a depth of approximately 50 feet (15m). Shading indicates less than 50 feet (15m) to ground water.

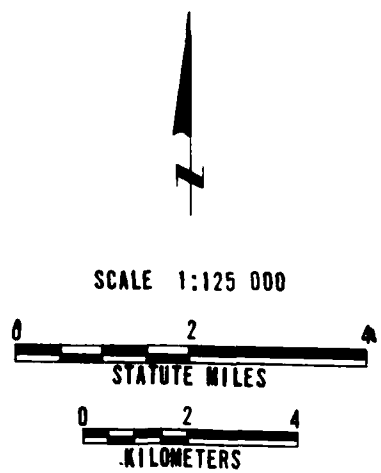
150 — Contour indicates ground water at a depth of approximately 150 feet (46m). Hachuring indicates less than 150 feet (46m) to ground water.

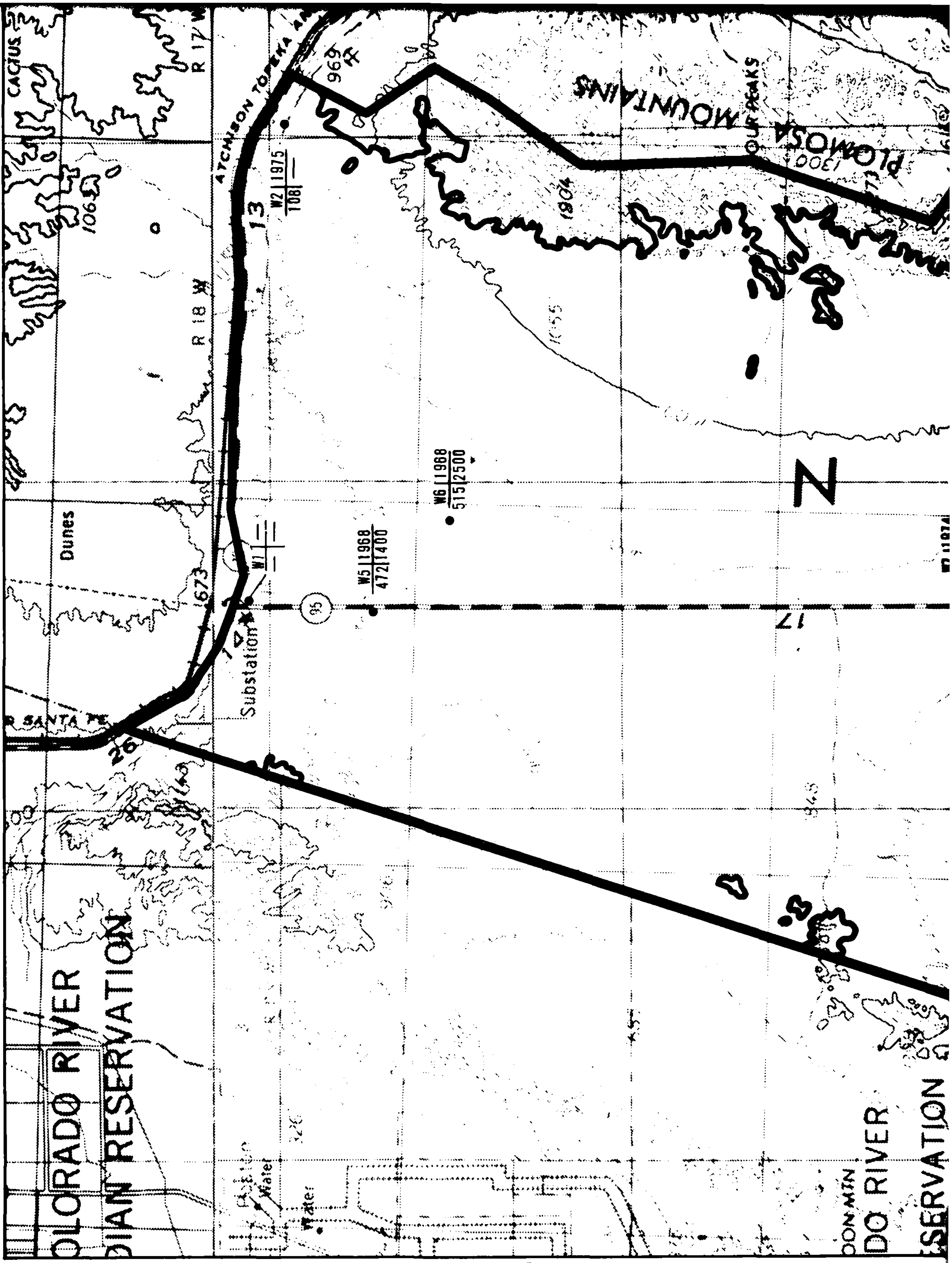
Contact between rock and basin-fill

Shading indicates areas of isolated exposed rock.

W2 | 1973	
Data Source Fugro boring (B), seismic refraction line (S), electrical resistivity sounding (R), or water well (W): see Volume IV Section 2.0.	Year of water level measurement
75 | 700	
Depth to water (feet)	Depth of well (feet)

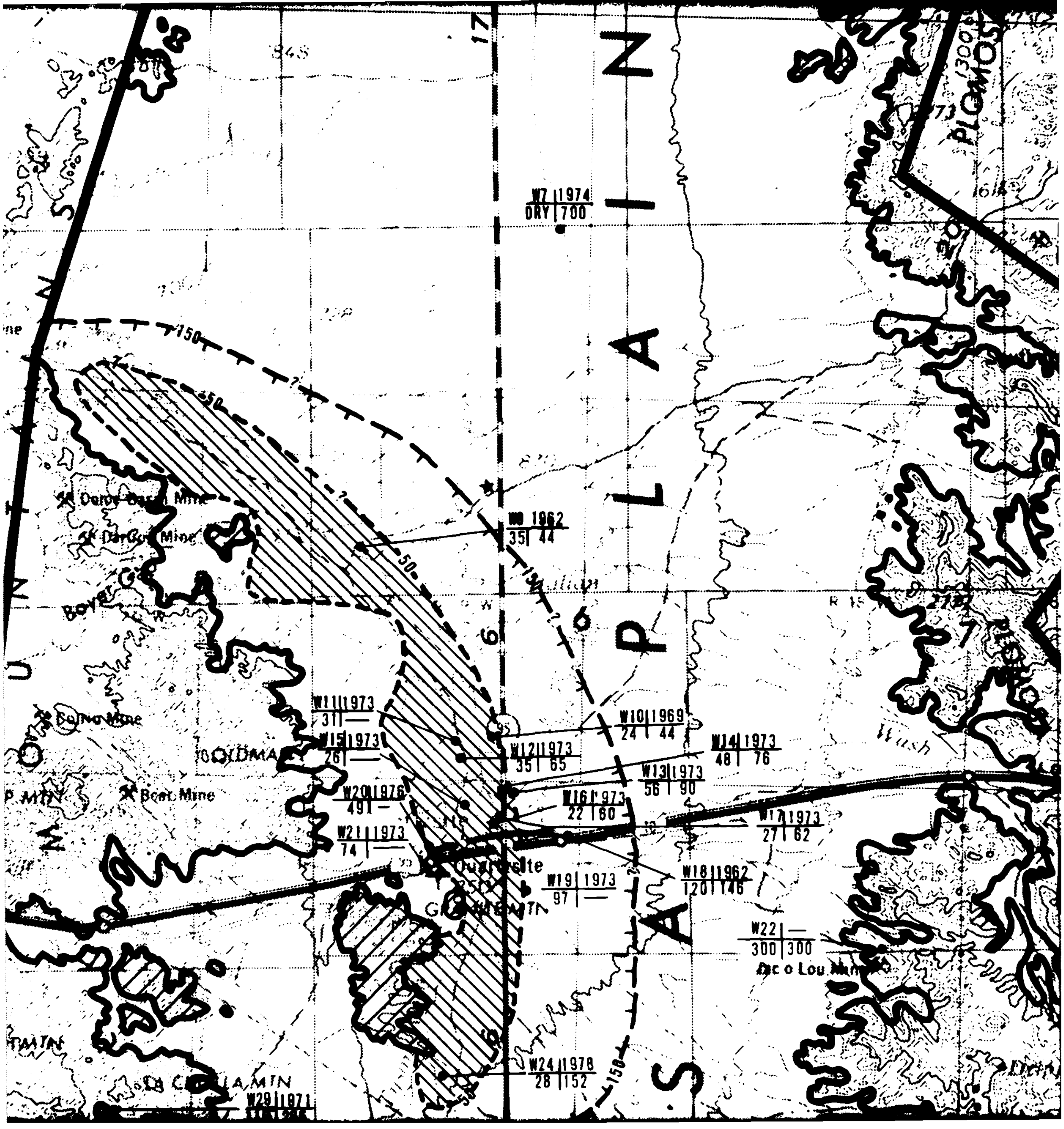
NOTE: The contours are based entirely on the data points shown on the map. Extensive interpretation has been used and it can be expected that contour locations will change as additional data are obtained.

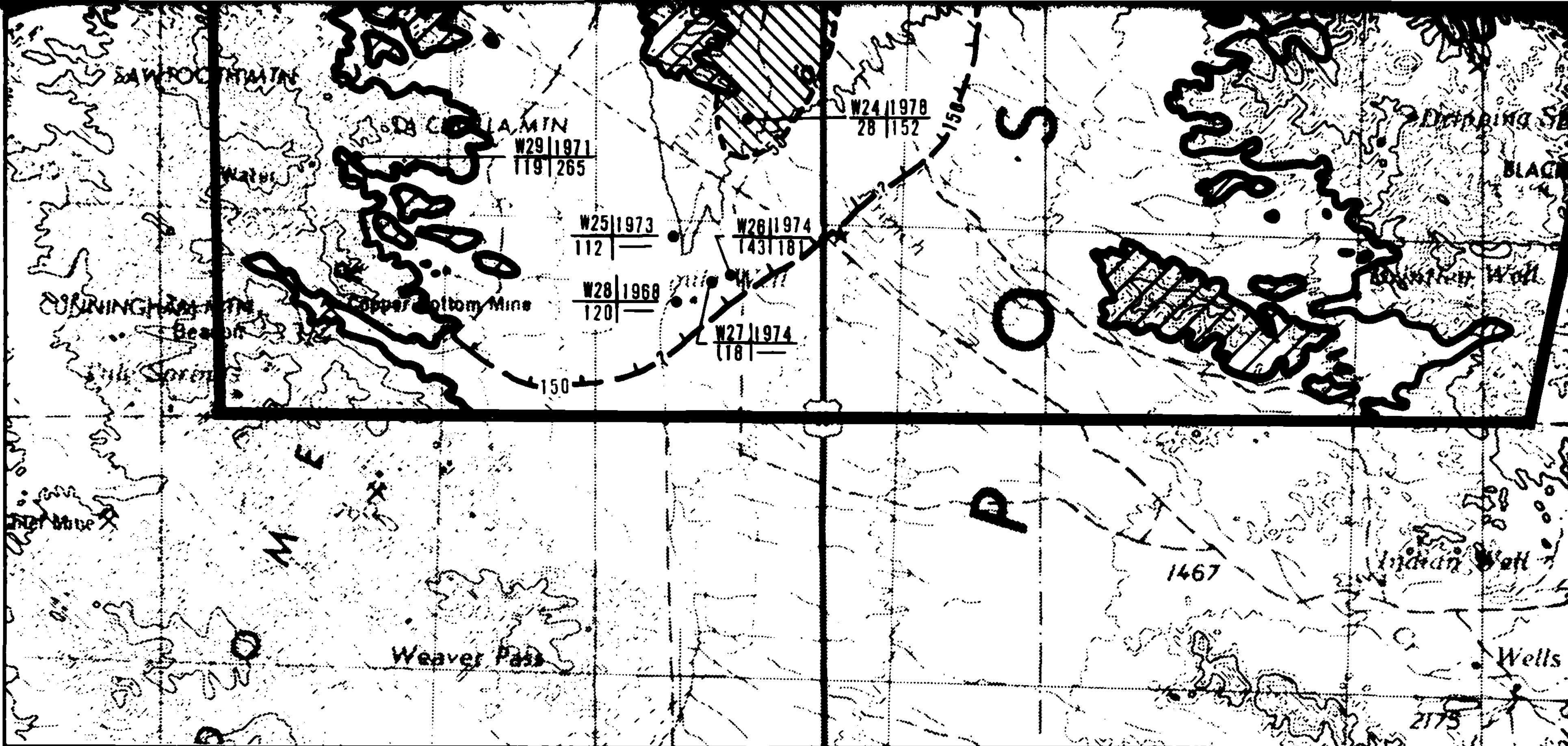




CACTUS
R 17 W
R 18 W
1065
ATCHISON TOPEKA
969
W2 1975 / 108 —
13
PLOMOSA MOUNTAINS
1904
Dunes
673
W1
W5 1968 / 472 1400
W6 1968 / 515 2500
95
Substation
SANTA FE
26
Z
17
COLORADO RIVER INDIAN RESERVATION
Water
DO RIVER
SERVATION

10 AUG 79


PLAINS
PLOMOSA
W7 | 1974
DRY | 700
W8 1962
35 | 44
W10 | 1969
24 | 44
W14 | 1973
48 | 76
W12 | 1973
35 | 65
W13 | 1973
56 | 90
W16 | 1973
22 | 60
W17 | 1973
27 | 62
W18 | 1962
120 | 146
W19 | 1973
97 | —
W22 | —
300 | 300
W24 | 1978
28 | 152
W11 | 1973
31 | —
W15 | 1973
26 | —
W20 | 1976
49 | —
W21 | 1973
74 | —
W29 | 1971
150
50
Darby Mine
Boner Mine
Bent Mine
Lou Mine
Wash
17
6
GRANITE MTN



EXPLANATION

50 — Contour indicates ground water at a depth of approximately 50 feet (15m). Shading indicates less than 50 feet (15m) to ground water.

— 150 — Contour indicates ground water at a depth of approximately 150 feet (46m). Hachuring indicates less than 150 feet (46m) to ground water.

Contact between rock and basin-fill

1 - 2

EXPLANATION

50 — Contour indicates ground water at a depth of approximately 50 feet (15m). Shading indicates less than 50 feet (15m) to ground water.

150 — Contour indicates ground water at a depth of approximately 150 feet (46m). Hachuring indicates less than 150 feet (46m) to ground water.

Contact between rock and basin-fill

Shading indicates areas of isolated exposed rock.

W2 | 1973 / 75 | 700

Data Source Fugro boring (B), seismic refraction line (S), electrical resistivity sounding (R), or water well (W): see Volume IV Section 2.0.	Year of water level measurement
Depth to water (feet)	Depth of well (feet)

NOTE: The contours are based entirely on the data points shown on the map. Extensive interpretation has been used and it can be expected that contour locations will change as additional data are obtained.

SCALE 1:125,

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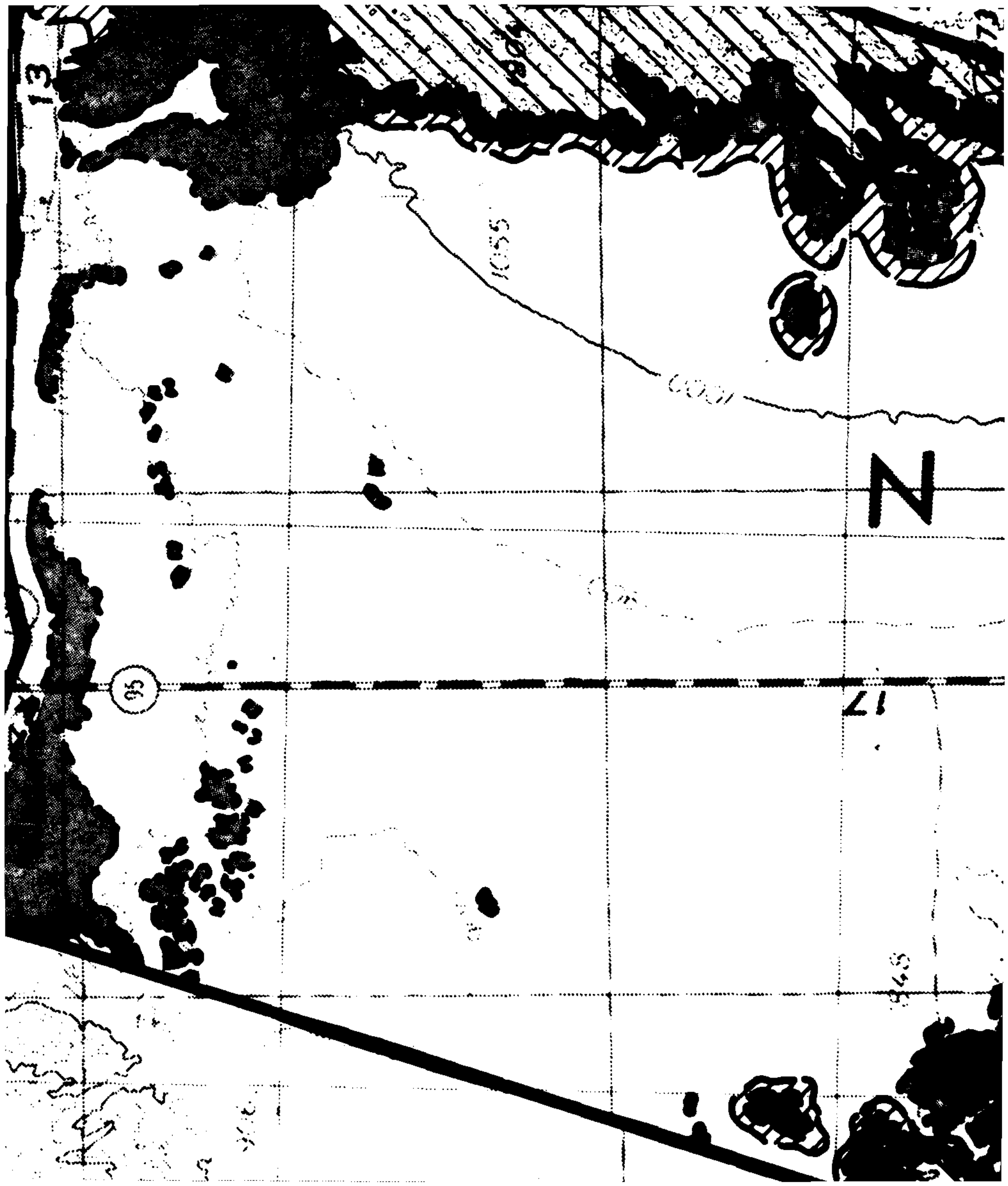
0 2 KILOMETERS

DEPTH TO WATER
VERIFICATION SITE, LA POSA CDP, ARIZONA

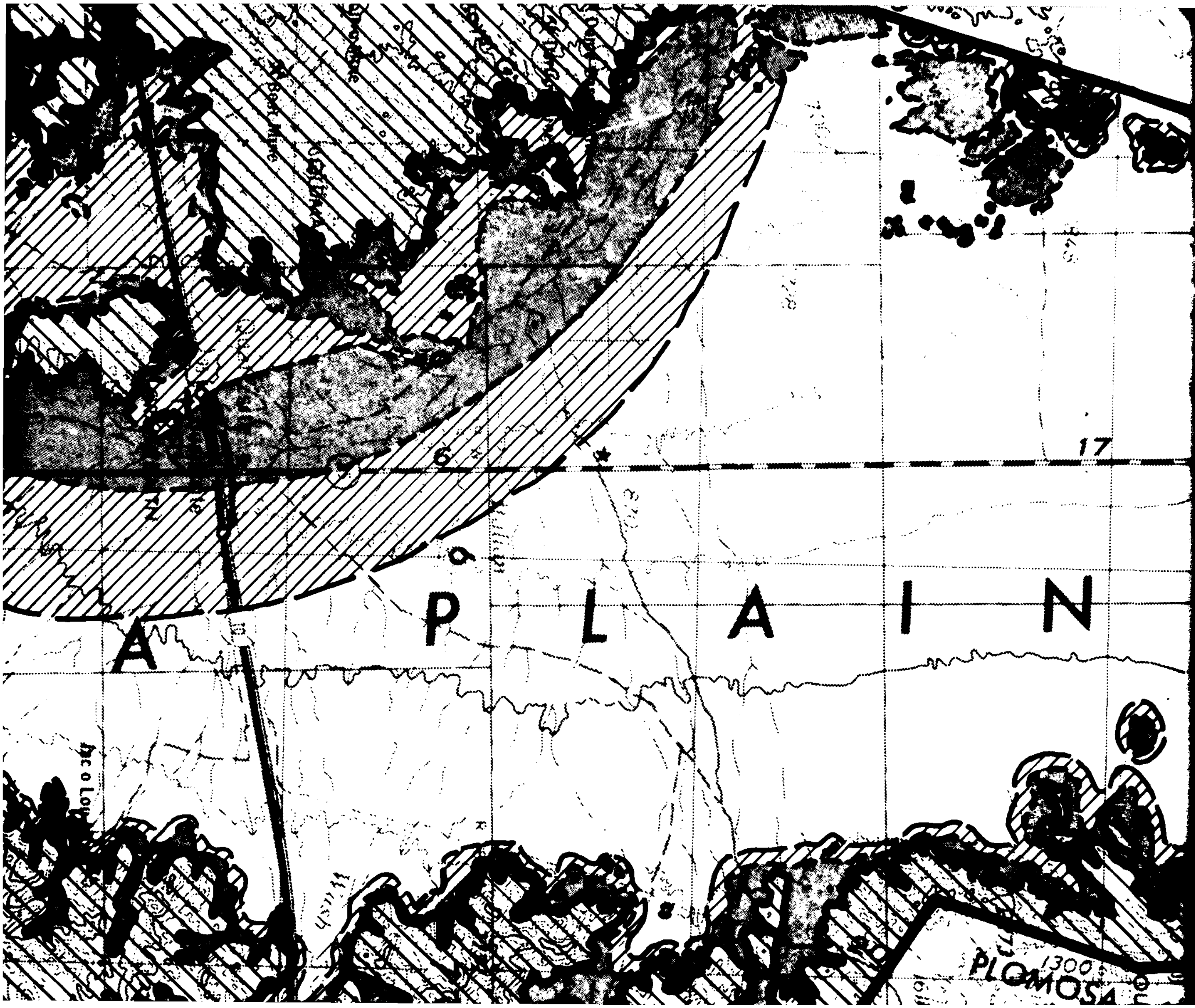
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

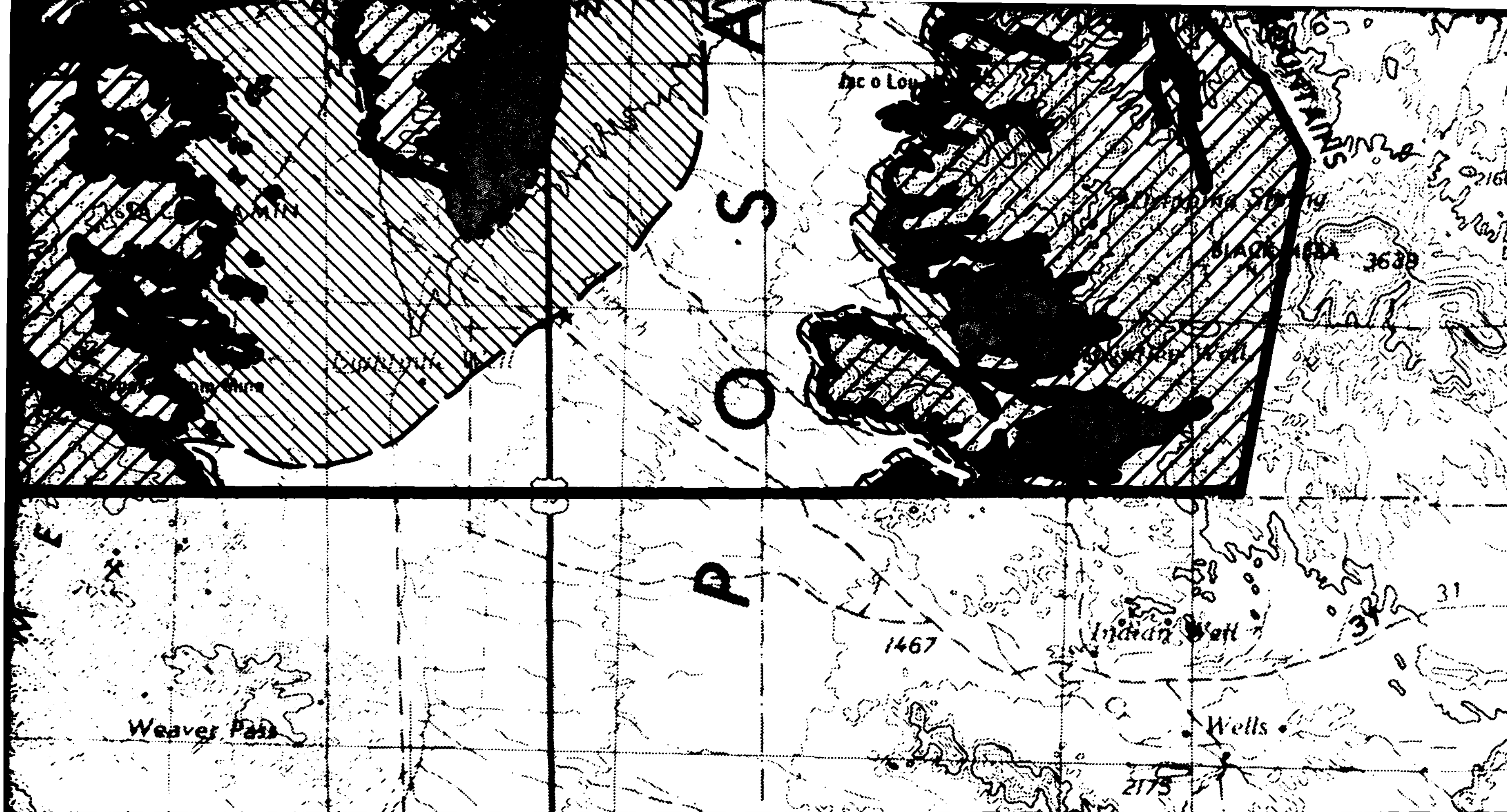
DRAWING 3-5

FUGRO NATIONAL, INC.



13
1055
1000
N
95
17
945


A
PLAIN
17
PLOMOSA
1300

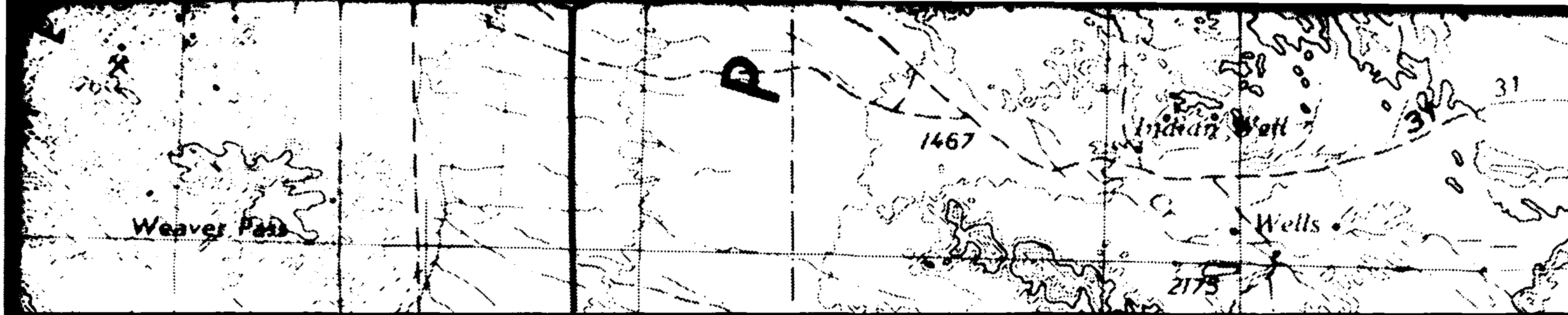


EXPLANATION

Area suitable for hybrid trench and vertical shelter basing modes. Depth to rock and water greater than 150 feet (46m)

Area suitable for hybrid trench and not suitable for vertical shelter. Depth to rock and water greater than 50 feet (15m) and less than 150 feet (46m)

Area unsuitable for both hybrid trench and vertical

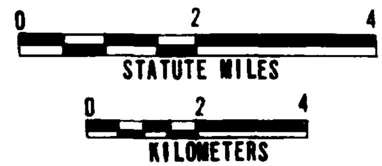


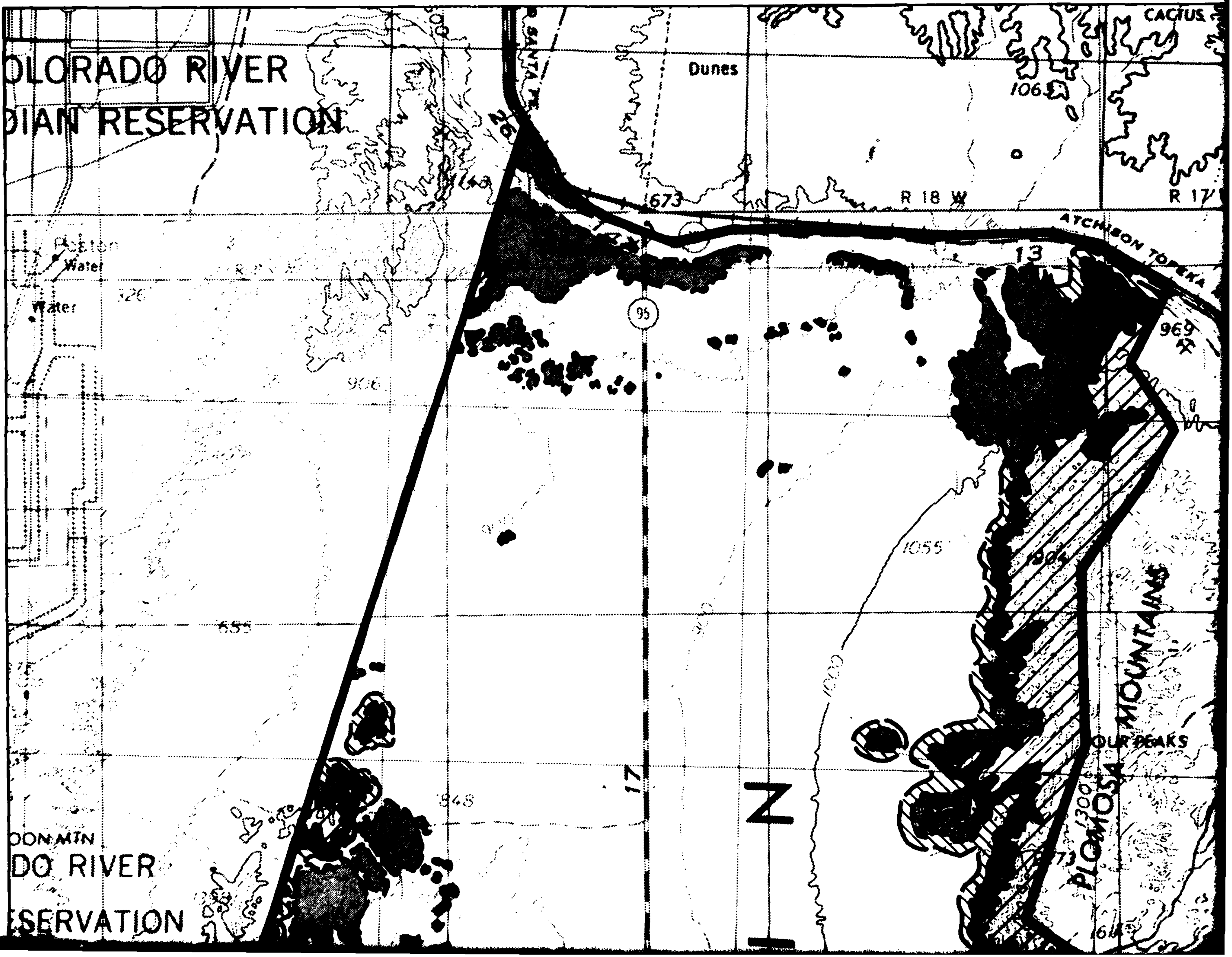
EXPLANATION

- Area suitable for hybrid trench and vertical shelter basing modes. Depth to rock and water greater than 150 feet (46m)
- Area suitable for hybrid trench and not suitable for vertical shelter. Depth to rock and water greater than 50 feet (15m) and less than 150 feet (46m)
- Area unsuitable for both hybrid trench and vertical shelter basing modes as determined from application of depth to rock and water, topographic/terrain, and cultural exclusions.
- Shading indicates areas of exposed rock.
- Contact between rock and basin-fill.

NOTE: See Appendix A2.0 Table A2-1 for details regarding suitable criteria.

SCALE 1:125,000




OLORADO RIVER
DIAN RESERVATION
Dunes
SANTA FE
ATCHISON TOPEKA
R 18 W
R 17
CACTUS
1065
673
26
13
95
969
Water
Water
906
1055
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1300
OON MTN
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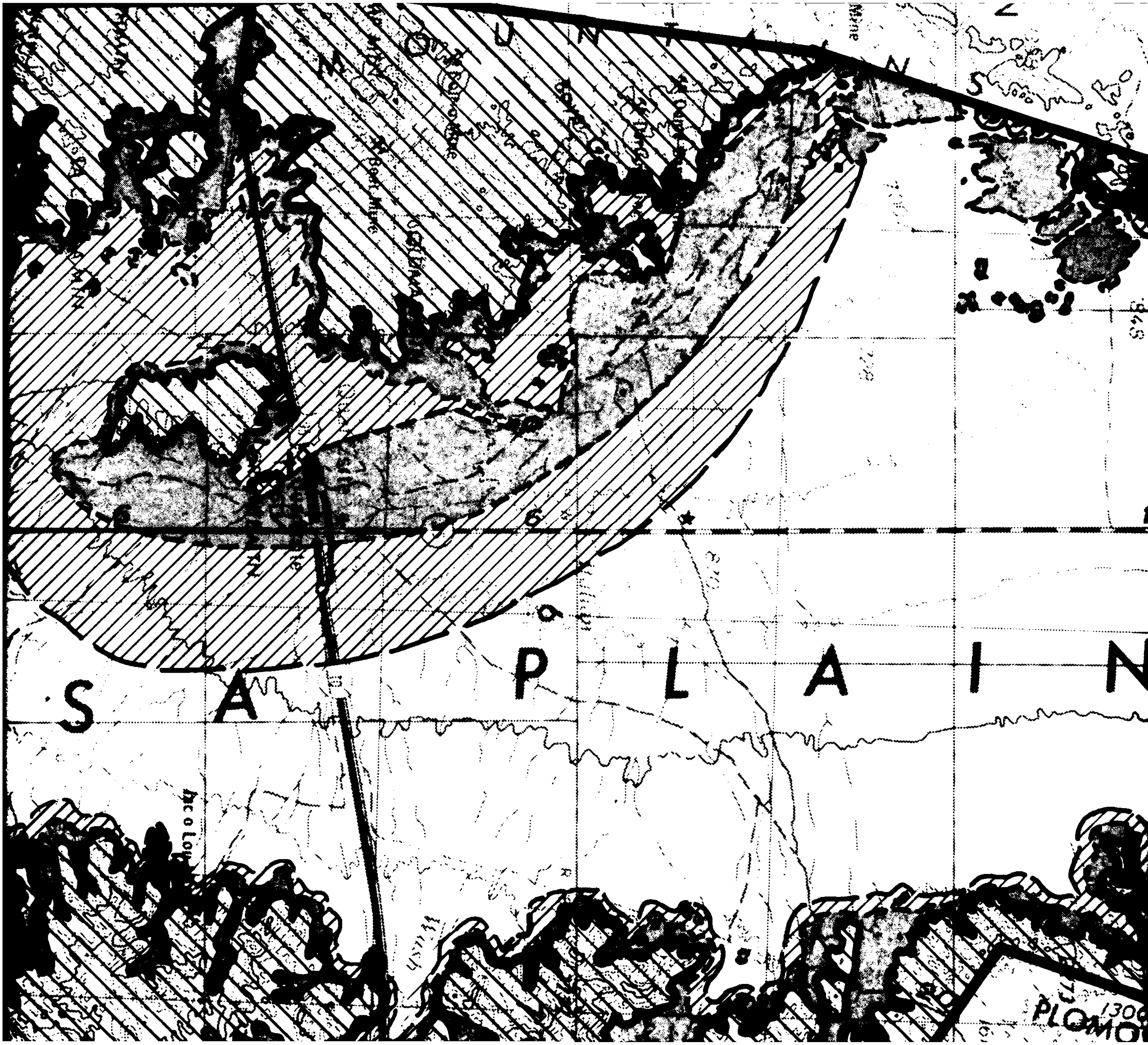
SERVATION

10 AUG 79

5


S A P L A I N
PLOMO
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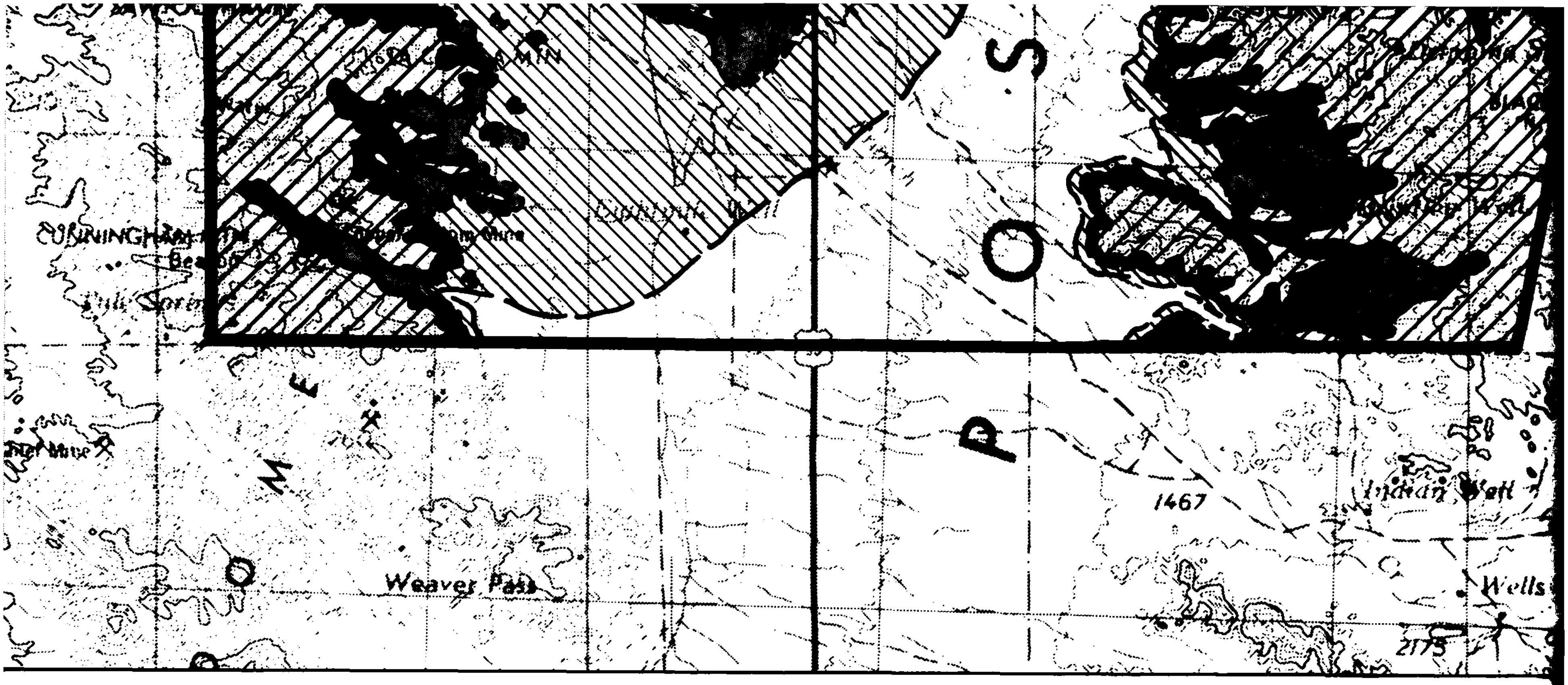

EXPLANATION

- Area suitable for hybrid trench and vertical shelter basing modes. Depth to rock and water greater than 150 feet (46m)
- Area suitable for hybrid trench and not suitable for vertical shelter. Depth to rock and water greater than 50 feet (15m) and less than 150 feet (46m)
- Area unsuitable for both hybrid trench and vertical shelter basing modes as determined from application of depth to rock and water, topographic/terrain, and cultural exclusions.
- Shading indicates areas of exposed rock.
- Contact between rock and basin-fill.

SCALE 1:125,000

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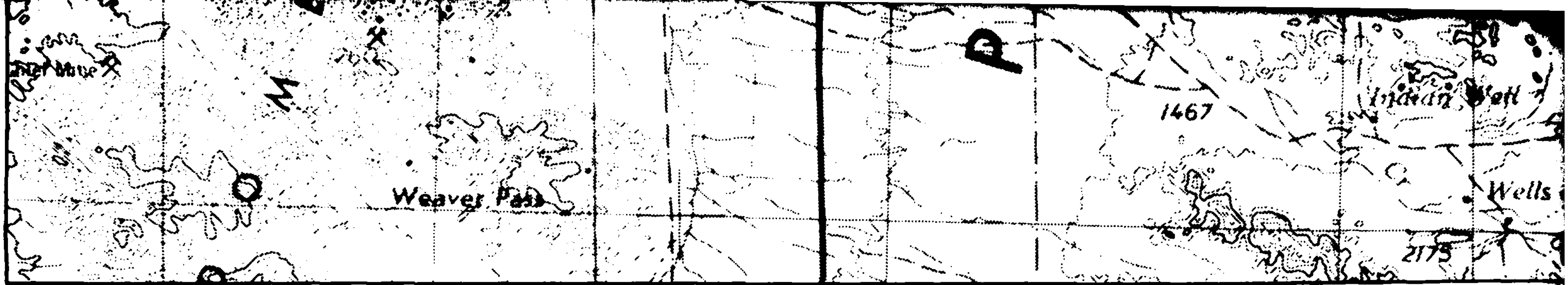

EXPLANATION

- Area suitable for hybrid trench and vertical shelter basing modes. Depth to rock and water greater than 150 feet (46m)
- Area suitable for hybrid trench and not suitable for vertical shelter. Depth to rock and water greater than 50 feet (15m) and less than 150 feet (46m)
- Area unsuitable for both hybrid trench and vertical shelter basing modes as determined from application of depth to rock and water, topographic/terrain, and cultural exclusions.
- Shading indicates areas of exposed rock.
- Contact between rock and basin-fill.

NOTE: See Appendix A2.0 Table A2-1 for details regarding suitable criteria

SCALE 1:125,000

0 2 STATUTE MILES

0 2 4 KILOMETERS

SUITABLE AREA
HYBRID TRENCHAAND VERTICAL SHELTER
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING 3-8

FUGRO NATIONAL, INC.

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8

4.0 BUTLER CDP

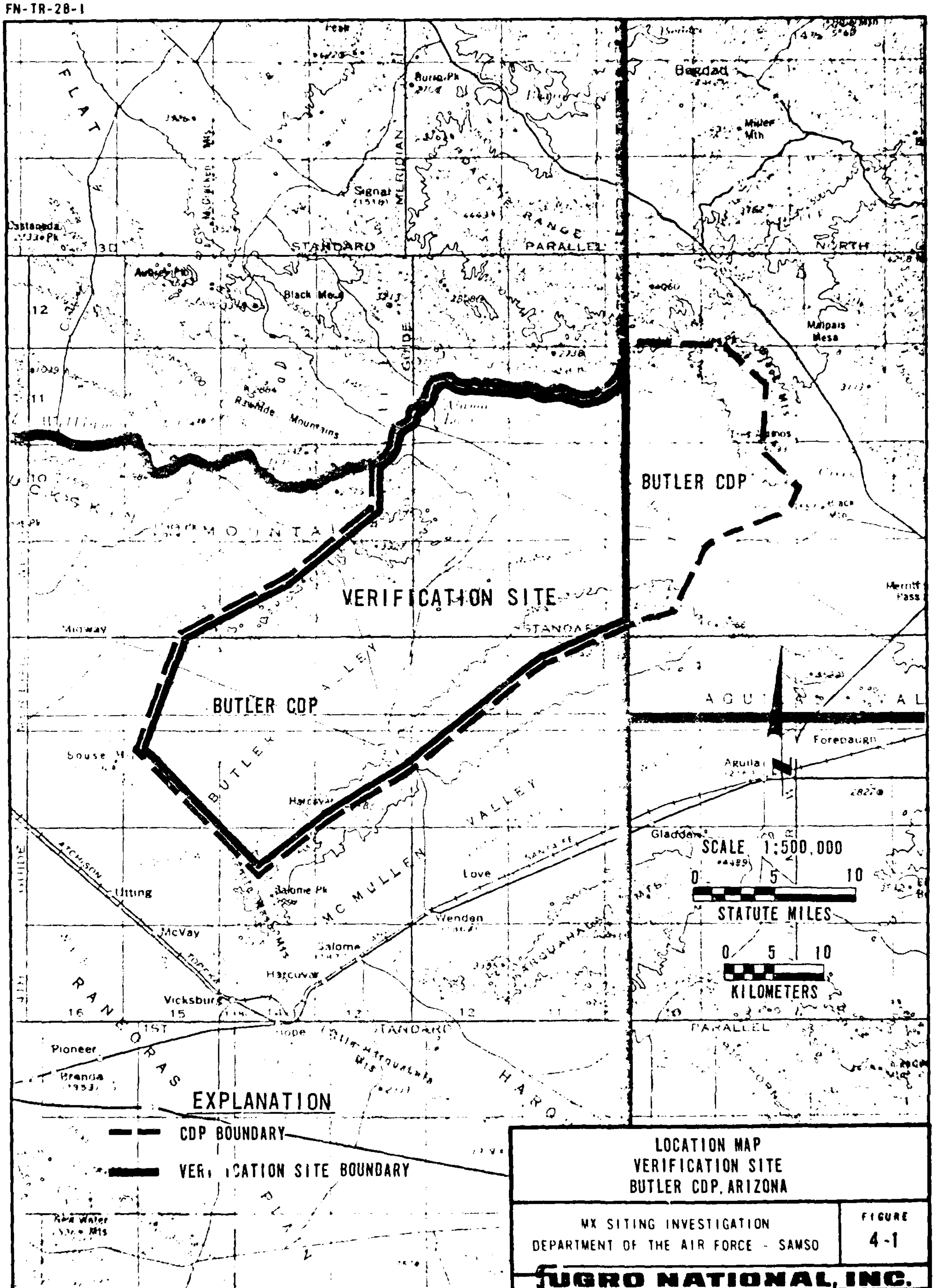
4.1 GEOGRAPHIC SETTING

Butler CDP is located in northern Yuma and southwestern Yavapai counties, Arizona (Figure 4-1). The CDP is bounded on the north by the Buckskin Mountains and Santa Maria River and on the south by the Harcuvar Mountains. It extends east to the Black Mountains, including the entire Date Creek Basin, and west to the pass into Ranegras Plain. The Verification site includes that part of the CDP which lies in Yuma County.

The only paved access into the site connects State Highway 72 south of the site with Alamo Reservoir on the Santa Maria River at the northern edge. Access within the site is good due to several major utility rights-of-way and numerous unpaved ranch roads. The towns of Salome and Wenden are approximately 10 miles (16 km) south of the site along Highway 72. Bouse is approximately 25 miles (40 km) west of Salome and Parker is another 25 miles northeast of Bouse. The majority of the CDP is undeveloped BLM rangeland with the exception of several sections in southwestern Butler leased for agriculture.

4.2 SCOPE

The scope of geologic, geophysical, and soils engineering field activities performed at the site and laboratory tests performed on soil samples from the site are presented in Table 4-1. Locations of the geophysical and engineering activities are shown in Drawing 4-1 (end of Section 4.0).


VERIFICATION SITE
BUTLER CDP
BUTLER CDP
Bagdad
Signal
STANDARD
PARALLEL
NORTH
Black Mesa
Malpais Mesa
Rawhide Mountains
Tres Alamos
Midway
Souse
Harcuvar
Salome Pk
McMULLEN VALLEY
BUTLER VALLEY
Love
Wenden
Utting
McVay
Salome
Harcuvar
Vicksburg
Hope
Pioneer
Brenda
Aguila
Forepaugh
Gladden
Merritt Pass
SCALE 1:500,000
0 5 10
STATUTE MILES
0 5 10
KILOMETERS
EXPLANATION
CDP BOUNDARY
VERIFICATION SITE BOUNDARY
LOCATION MAP
VERIFICATION SITE
BUTLER CDP, ARIZONA
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO
FIGURE
4-1
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GEOLOGY AND GEOPHYSICS

TYPE OF ACTIVITY	NUMBER OF ACTIVITIES
Geologic mapping stations	66
Shallow refraction	16
Electrical resistivity	14
Gravity profiles	8

ENGINEERING-LABORATORY TESTS

TYPE OF TEST	NUMBER OF TESTS
Moisture/density	95
Specific gravity	7
Sieve analysis	88
Hydrometer	1
Atterberg limits	15
Consolidation	0
Unconfined compression	0
Triaxial compression	0
Direct shear	9
Compaction	6
CBR	6
Chemical analysis	13

ENGINEERING

NUMBER OF BORINGS	NOMINAL DEPTH FEET (METERS)
5	160 49
NUMBER OF TRENCHES	NOMINAL DEPTH FEET (METERS)
4	14 (4)
1	10 (3)
NUMBER OF TEST PITS	NOMINAL DEPTH FEET (METERS)
25	5 (2)
NUMBER OF CPTs	RANGE OF DEPTH FEET (METERS)
66	2-22 (1-7)
TYPE OF ACTIVITY	NUMBER OF ACTIVITIES
Surficial soil samples	32
Field CBR tests	0

SCOPE OF ACTIVITIES
VERIFICATION SITE, BUTLER CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 4-1

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4.3 GEOLOGIC SETTING

The Little Buckskin, Buckskin, and the Harcuvar mountains are composed of Precambrian granite gneiss locally intruded by Laramide granite (Wilson et al., 1969; Gassaway, 1977). Mesozoic sediments consisting of sandstone and conglomerate outcrop on the southern end of the Buckskin Mountains. Mesozoic granite is exposed on the east end of the Bouse Hills at the western edge of the site. Numerous outcrops of Tertiary conglomerate are exposed throughout the site, the most prominent of which is located on the southern end of the Little Buckskin Mountains as Black Butte. Tertiary volcanic rocks and uranium-bearing vulcaniclastic sediments are exposed along the Santa Maria River and underlie alluvium along the northern edge of the site (Sherborne et al., 1979; Pierce, 1977).

Butler Valley and the adjacent mountain ranges exhibit a northeast-southwest trend, transverse to the regional north to northwesterly trend prevalent in this portion of the Basin and Range Province. This anomalous trend may be the result of a structural setting predating basin and range faulting.

No active basin-margin faults have been identified in Butler Valley. Gassaway (1977) has shown numerous bedrock faults in the Buckskin Mountains, some of which are projected under the basin-fill materials. Gassaway (1977) also recognized an east-west lineament paralleling the Santa Maria River in the northern end of the site. No faults displacing basin-fill deposits have been recognized.

Alluvial fan deposits are the predominant surficial geologic unit in the Butler site (Drawing 4-2). Older alluvial fan deposits predominate in eastern Butler in the Date Creek Basin area. Quaternary-Tertiary lacustrine and alluvial deposits of interbedded clay, silt, and sand are exposed in Date Creek and locally throughout the area north of Date Creek. Moderately to strongly cemented older alluvial fan deposits, consisting of sandy gravels, are exposed south of Date Creek along the Harcuvar Mountains.

Young alluvial fan deposits predominate in western Butler Valley, west of the Little Buckskin Mountains. Deposits consist chiefly of sand, with gravel found locally near mountain fronts. Intermediate alluvial fans around the basin periphery are generally gravelly sands and gravel. Eolian sands occur adjacent to Cunningham Wash along the valley axis.

4.4 SURFACE SOILS

The surficial soils of the Butler Site are predominantly coarse-grained (granular). Soils from predominant surficial geologic units (Drawing 4-2) have been grouped into the following categories based on their physical and engineering characteristics.

1. Sands, silty sands, and clayey sands (from geologic units A5ys and A5is).
2. Sandy gravels and gravelly sands (from geologic units A5ys, A5is, A5ig, and A5og).
3. Sandy silts and sandy clays (from geologic units A5of, A5ys, and A5is).

4.4.1 Characteristics

The characteristics of surficial soils, based on field and laboratory test results, are summarized in Table 4-2. In addition to the physical characteristics, road design data consisting of laboratory compaction and California Bearing Ratio (CBR) test results, depth range and average depth of low-strength surficial soils, and evaluation of soils for road use are included in the table. The range of gradation of surficial soils is presented in Figure 4-2.

Sands, silty sands, and clayey sands are the predominant soil types with an approximate areal distribution ranging from 60 to 75 percent of the site. Sands are located in all portions of the site but are most common in the young alluvial fans of central valley areas. They are predominantly poorly graded, contain traces to appreciable amounts of fines, and often contain gravel traces. Soil plasticity ranges from none to slight. Weakly to moderately developed calcium carbonate cementation is locally encountered in sands within 2 feet (0.6 m) of the ground surface.

Sandy gravels and gravelly sands have an approximate areal distribution of 20 to 30 percent. Some gravelly sands are found in active stream channels and young alluvial fans in central valley areas; however, the major concentrations are in intermediate and old fans near mountain fronts. These soils are mostly poorly graded and contain traces to appreciable fines. Soil plasticity ranges from none to slight. Moderately

SOIL DESCRIPTION		Sands, Silty Sands, and Clayey Sands		Sandy Grav
USCS SYMBOLS		SP, SM, SC		GP, GM
PREDOMINANT SURFICIAL GEOLOGIC UNITS		A5ys and A5is		A5is A5
ESTIMATED AREAL EXTENT %		60-75		20-30
PHYSICAL PROPERTIES				
COBBLES 3 – 12 inches (8 – 30 cm) %		0-5		0-10
GRAVEL %		0-17	[16]	24-47
SAND %		51-91	[16]	33-58
SILT AND CLAY %		8-43	[16]	5-23
LIQUID LIMIT		34	[2]	27
PLASTICITY INDEX		NP-11	[2]	10
ROAD DESIGN DATA				
MAXIMUM DRY DENSITY pcf (kg/m3)		124.5-125.9 (1994-2017)	[2]	123.0-13 (1970-2
OPTIMUM MOISTURE CONTENT %		7.4-9.5	[2]	6.8-10.
CBR AT 90% RELATIVE COMPACTION %		10-15	[2]	15-30
SUITABILITY AS ROAD SUBGRADE (1)		fair to good		good to
SUITABILITY AS ROAD SUBBASE OR BASE (1)		poor to fair		fair to
THICKNESS OF LOW STRENGTH SURFICIAL SOIL (2)	RANGE ft (m)	2.9-9.0 (0.9-2.7)	[41]	0.5-4. (0.2-1.
	AVERAGE ft (m)	5.3 (1.6)	[41]	1.9 (0.6)

(1) *Suitability is a subjective rating explained in Section A5.0 of the Appendix.*

(2) Low strength surficial soil is defined as soil which will perform poorly as a road subgrade at its present consistency; see Table 4-3 for details.

NOTES: •

•

Sandy Gravels and Gravelly Sands		Sandy Silts and Sandy Clays		
GP. GM GC. SP. SM and SC		ML and CL		
A5is A5ys. A5ig. and A5og		A5ys		
20-30		0-10		
0-10		0		
24 47	[10]	0-2	[3]	
33-58	[10]	34-49	[3]	
5-23	[10]	51-66	[3]	
27	[1]	21-26	[3]	
10	[1]	3-12	[3]	
123 0-136 7 (1970-2190)	[3]	125 5 (2010)	[1]	
6 8-10 9	[3]	9 1	[1]	
15-30	[3]	10	[1]	
good to very good		poor		
fair to good		not suitable		
0 5-4 8 (0 2-1 5)	[17]	0 8-4 2 (0 2-1 3)	[7]	
1.9 (0.6)	[17]	2 6 (0.8)	[7]	

[N]OTES:

- [ ] - Number of tests performed
- NDA - No data available (insufficient data or tests not performed)

CHARACTERISTICS OF SURFICIAL SOILS VERIFICATION SITE, BUTLER CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 4-2

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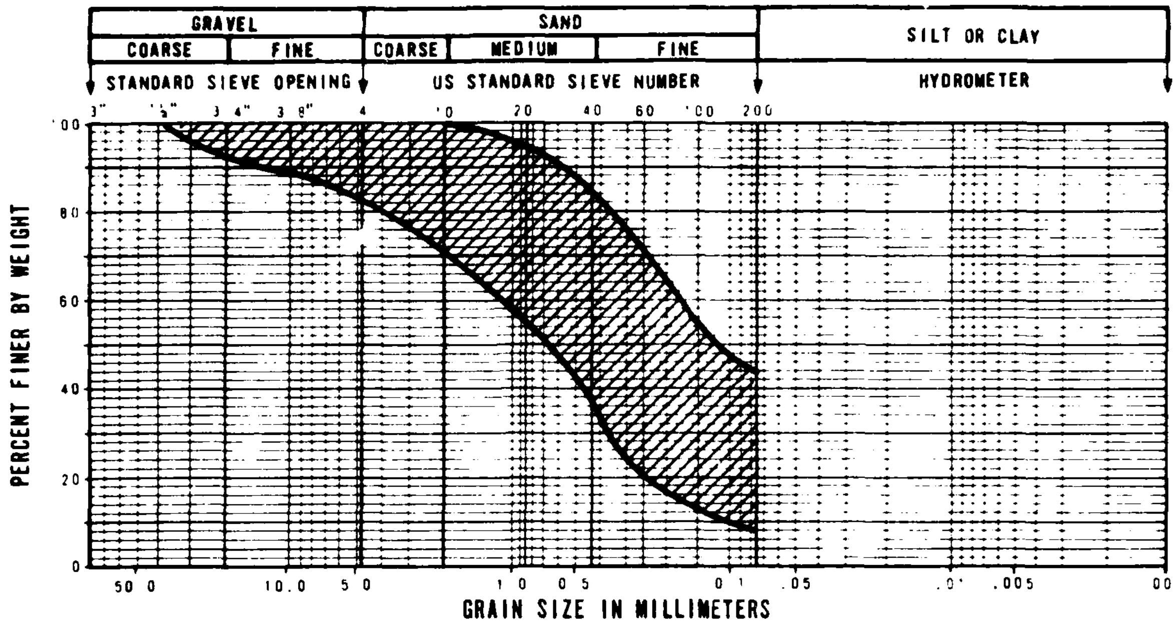
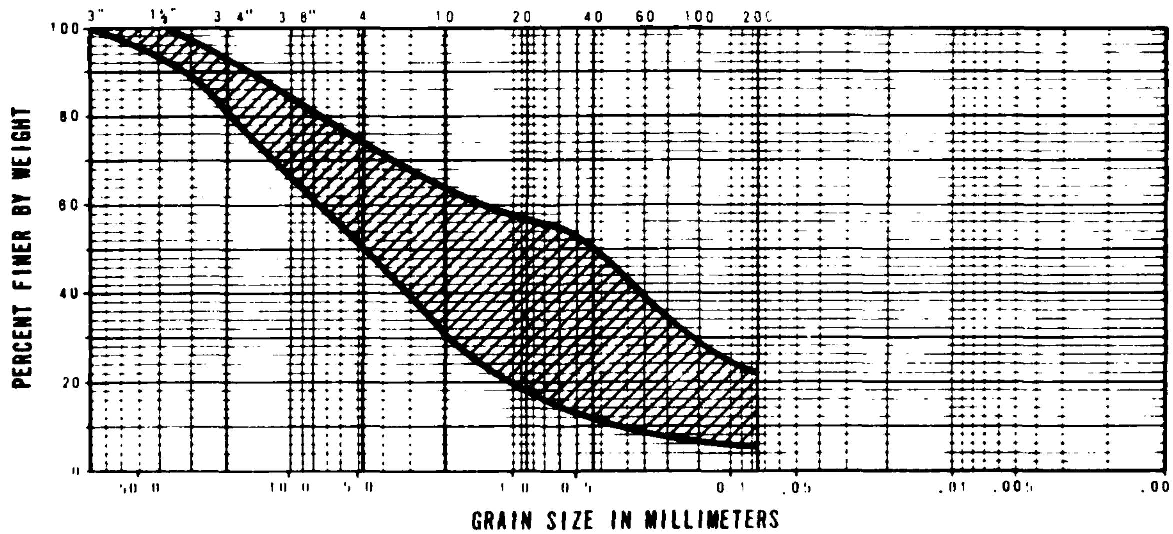
AFV-19



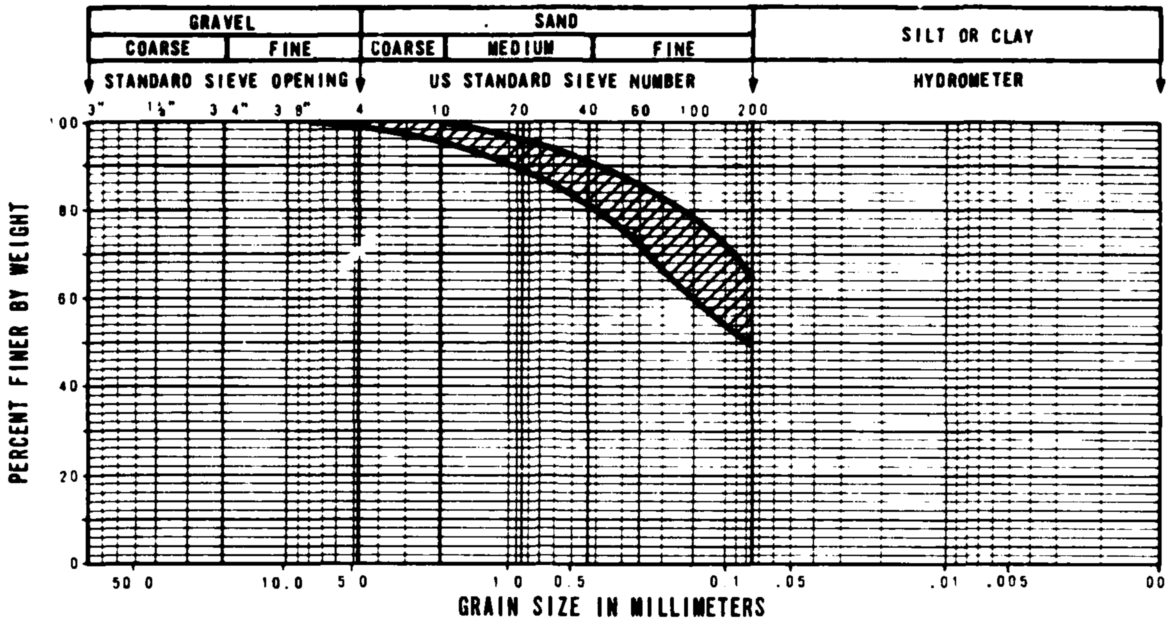
SOIL DESCRIPTION: Sands, silty sands and clayey sands from 0 to 2 feet (0.0 to 0 6m)



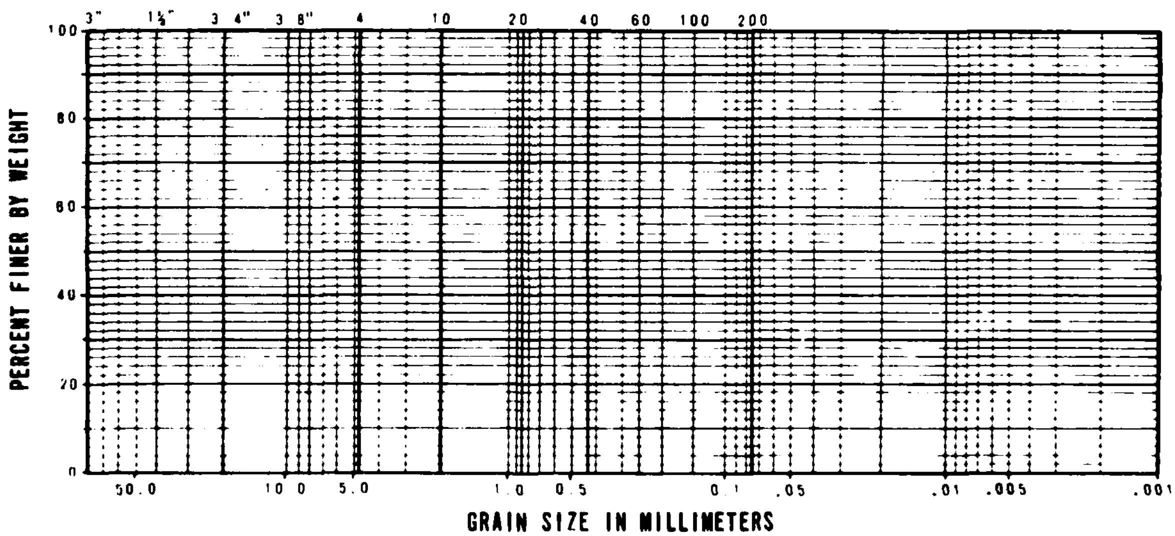
SOIL DESCRIPTION: Sandy gravels and gravelly sands from 0 to 2 feet (0 0 to 0 6m)

RANGE OF GRADATION OF SURFICIAL SOILS VERIFICATION SITE, BUTLER CDP, ARIZONA	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE SAMSO	FIGURE 4-2 1 OF 2

FUGRO NATIONAL, INC.



SOIL DESCRIPTION: Sandy silts and sandy clays from 0 to 2 feet (0.0 to 0.6m)



RANGE OF GRADATION OF SURFICIAL SOILS
VERIFICATION SITE, BUTLER CDP, ARIZONA

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	FIGURE 4-2 2 OF 2

FUGRO NATIONAL, INC.

to well-developed calcium carbonate cementation is often encountered below 2 feet (0.6 m) of the ground surface in gravelly soils of intermediate and old fans.

Sandy silts and sandy clays are the least common surficial soil type, covering less than 10 percent of the site. These soils generally occur in old lacustrine deposits in northeast Butler and as isolated pockets in young and intermediate alluvial fans. Fine-grained soils typically contain appreciable amounts of sand and locally traces of gravel. Soil plasticity ranges from none to medium, and soils are usually uncemented to weakly cemented in the surficial zone.

4.4.2 Low-Strength Surficial Soil

Cone Penetrometer Test (CPT) results were used in conjunction with soil classifications to evaluate in-situ surficial soils. The thickness of low-strength surficial soil at each CPT location was estimated and is tabulated in Table 4-3. The range and mean thickness of the low-strength soils are summarized in Table 4-2. Sands exhibit low strength to depths ranging from 2.9 to 9.0 feet (0.9 to 2.7 m) with an average of 5.3 feet (1.6 m). Gravelly sands and sandy gravels exhibit low strength to depths ranging from 0.5 to 4.8 feet (0.2 to 1.5 m) with an average of 1.9 feet (0.6 m). Variations in the extent of low-strength, granular, surficial soils are caused by differences in particle size, density, and degree of cementation. Fine-grained soils exhibit low strengths to depths ranging between 0.8 and 4.2 feet (0.2 and 1.3 m) with an average of 2.6 feet

CONE PENETROMETER TEST NUMBER(1)	THICKNESS OF LOW STRENGTH SURFICIAL SOIL (2)		SOIL TYPE (3)
	FEET	METERS	
C-1	2.0	0.6	SP-SM CL
C-2	4.7	1.4	SM
C-3	3.9	1.2	SM SC
C-4	2.3	0.7	SP
C-5	1.0	0.3	SM
C-6	3.6	1.1	SM
C-7	2.9	0.9	ML
C-8	5.5	1.7	SM
C-9	4.5	1.4	SM SP-SM
C-10	5.5	1.7	SM
C-11	4.0	1.2	SM
C-12	4.8	1.5	SM
C-13	2.4	0.7	SC SM
C-14	0.8	0.2	CL
C-15	2.8	0.9	SC SP-SC
C-16	5.2	1.6	SM
C-17	2.0	0.6	SM GP-GM
C-18	0.8	0.2	SM
C-19	4.0	1.2	CL SP-SM
C-20	4.1	1.2	SM SP-SM
C-21	1.5	0.5	SM
C-22	1.7	0.5	GP-GM
C-23	1.3	0.4	SM GP-GM
C-24	2.4	0.7	SP-SM
C-25	4.8	1.5	GP
C-26	1.2	0.4	GP GC
C-27	1.8	0.5	GM
C-28	4.0	1.2	SC

CONE PENETROMETER TEST NUMBER(1)	THICKNESS OF ... SURFICIA...
	FEET
C-29	3.6
C-30	0.5
C-31	8.0
C-32	6.0
C-33	6.5
C-34	4.9
C-35	3.5
C-36	8.3
C-37	7.2
C-38	5.4
C-39	4.0
C-40	5.6
C-41	9.0
C-42	6.2
C-43	4.0
C-44	6.8
C-45	3.1
C-46	4.2
C-47	7.2
C-48	0.6
C-49	7.7
C-50	5.7
C-51	4.1
C-52	7.1
C-53	2.3
C-54	3.9
C-55	4.6
C-56	2.8

(1) For Cone Penetrometer Test locations see Drawing Activity Location Map.

(2) Thickness corresponds to depth below ground surface. Low strength surficial soil is defined as soil which will perform poorly as a road subgrade at its present consistency. Low strength is based on Cone Penetrometer Test results using the following criteria:

Coarse grained soils: $q_c < 120$ tsf (117 kg/cm^2)
Fine grained soils: $q_c < 80$ tsf (78 kg/cm^2)

where q_c is cone resistance.

(3) Soil type is based on Unified Soil Classification System; see Section A5.0 in the Appendix for explanation

NOTES: • Fe... st... of...

• SM...

• NO...

...NESS OF LOW STRENGTH SURFICIAL SOIL.(2) FEET	METERS	SOIL TYPE (3)
.6	1.1	SM SP
.5	0.2	SM
.0	2.4	SM
.0	1.8	SM
.5	2.0	SM
.9	1.5	SM
.5	1.1	SM
.3	2.5	SM
.2	2.2	SM
.4	1.6	SM SP-SM
.0	1.2	SM
.6	1.7	SM
.0	2.7	SP-SM
.2	1.9	SP-SM
.0	1.2	SM
.8	2.1	SM
.1	0.9	ML
.2	1.3	ML
.2	2.2	SM
.6	0.2	GC/GM
.7	2.3	SM
.7	1.7	SM CL-SC
.1	1.2	SM
.1	2.2	SM
.3	0.7	ML SC
.9	1.2	SM
.6	1.4	SM GM
.8	0.9	CL

CONE PENETROMETER TEST NUMBER(1)	THICKNESS OF LOW STRENGTH SURFICIAL SOIL.(2) FEET	METERS	SOIL TYPE (3)
C-57	6.8	2.1	SM
C-58	3.9	1.2	CL SM
C-59	2.9	0.9	SC
C-60	4.0	1.2	SM
C-61	1.0	0.3	SM
C-62	5.8	1.8	SM SP-SM
C-63	0.7	0.2	SM
C-64	3.7	1.1	SM
C-65	3.3	1.1	SM
C-66	8.1	2.5	SM

...TES:
- For fine grained soils (ML, CL, MH and CH), thickness of low strength surficial soil will vary depending on moisture content of the soil at time of testing.
- SM/GM - indicates SM underlain by GM
- NDA - No data available

THICKNESS OF LOW STRENGTH SURFICIAL SOILS
VERIFICATION SITE, BUTLER COP, ARIZONA

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TABLE 4-3

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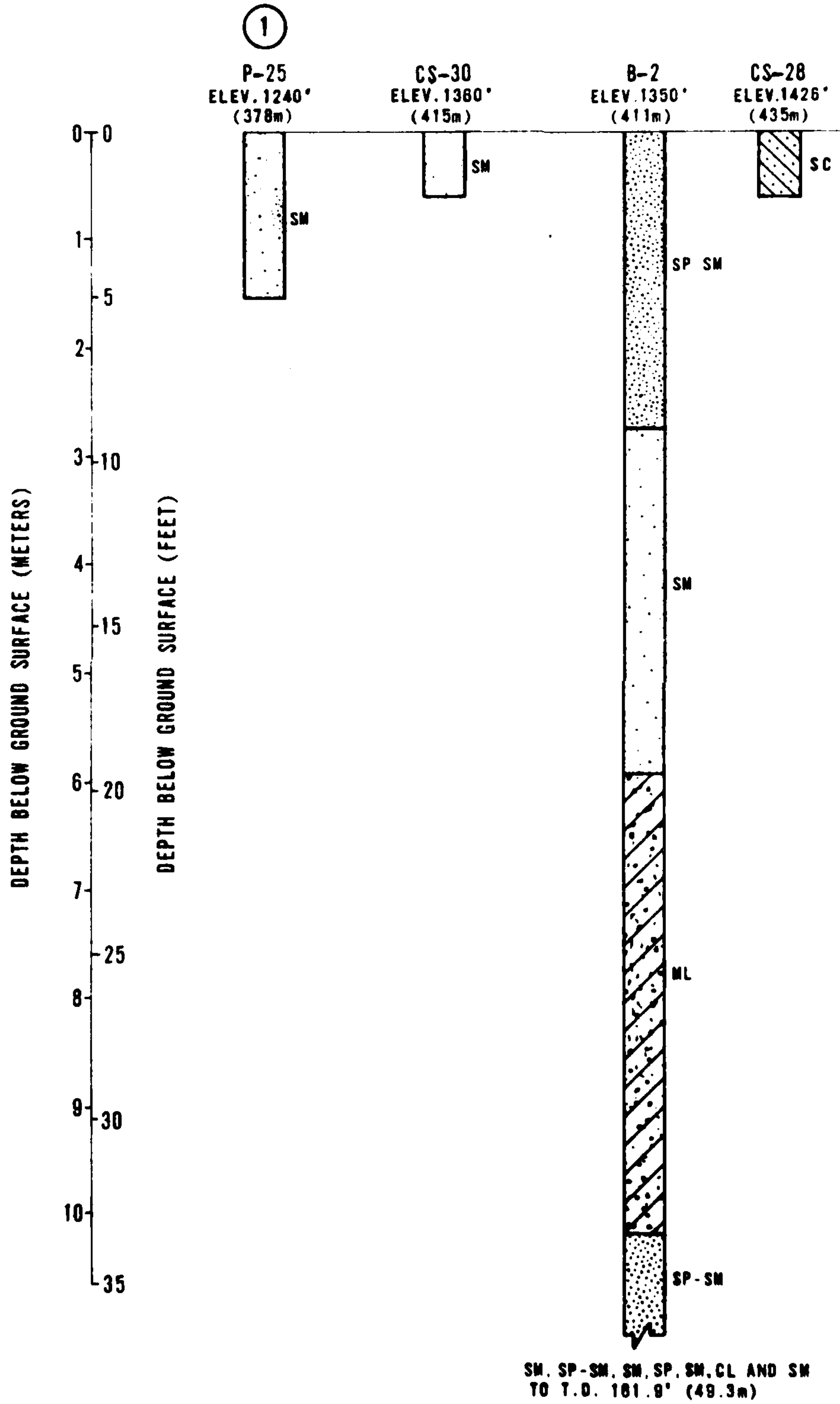
(0.8 m). The extent of low-strength fine-grained soils is influenced by density, soil moisture content, and cementation.

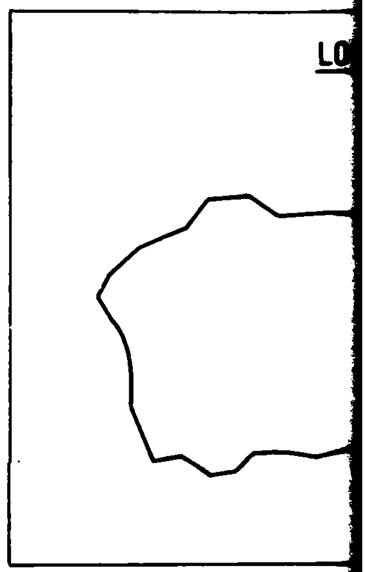
4.5 SUBSURFACE SOILS

Soil profiles, Figures 4-3 through 4-7, show the composition of subsurface soils with depth, as determined from borings, trenches, and test pits. Subsurface soils are predominantly coarse-grained (granular) alluvial fan deposits consisting of heterogeneous mixtures of sandy gravel, gravelly sand, sand, silty sand, and clayey sand with minor silt or clay interbeds. Silty sands are predominant in central valley areas with gravelly sands and gravels increasing near mountain fronts.

Results of seismic refraction and electrical resistivity surveys are summarized in Table 4-4. Characteristics of the subsurface soils, as determined from field and laboratory tests, are presented in Table 4-5. Gradation ranges of subsursurface soils are shown in Figure 4-8.

Below 10 feet (3 m), granular soils are dense to very dense and exhibit high shear strengths. Soils are mostly poorly graded with local, well-graded intervals. The granular deposits are typically nonplastic with random medium to high plasticity clayey sand layers. Fine-grained soil interbeds are of stiff to hard consistency with a plasticity range from none to medium. Soil layers with moderate to well-developed calcium carbonate cementation occur intermittently, but continuously cemented subsoils were not encountered.





EXPLANATION

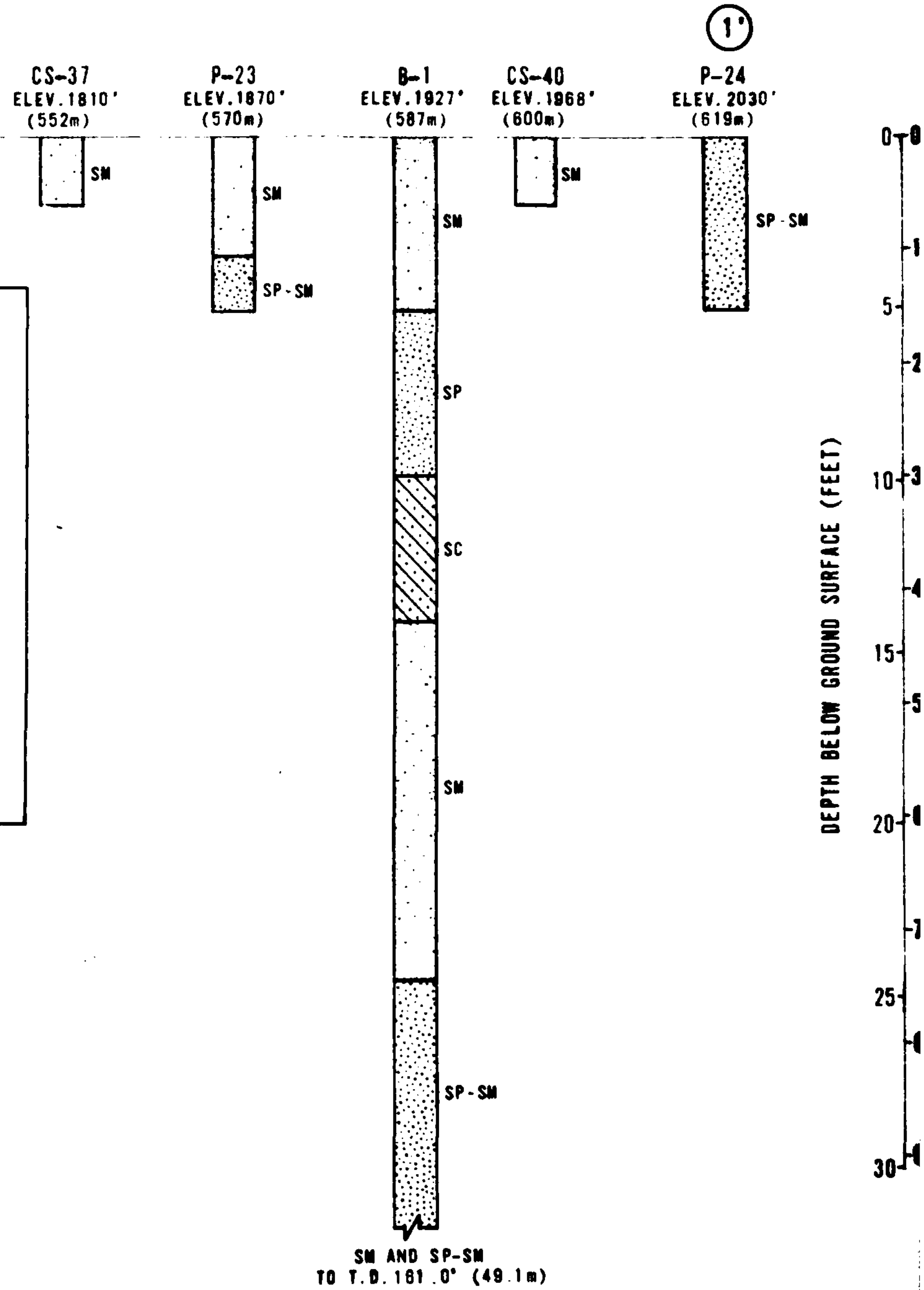
B - Boring
T - Trench
P - Test Pit
CS - Surficial soil sample at Cone Pe
Test location

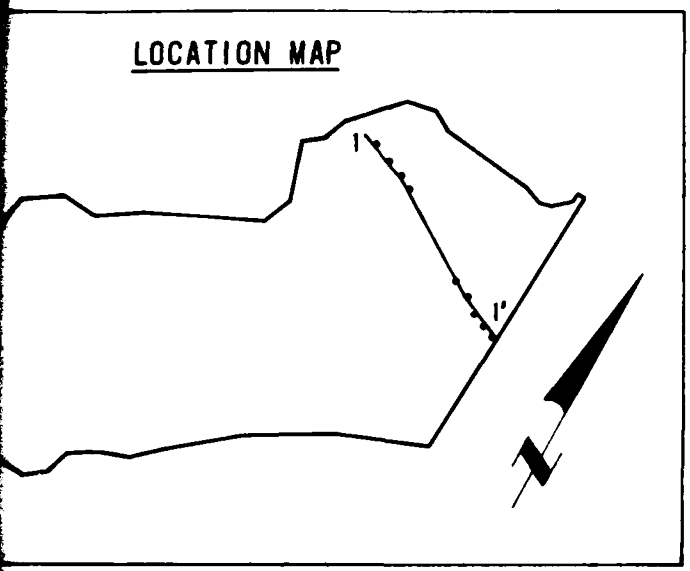
STATUTE MILES

KILOMETERS

NOTES:

1. Ground surface eleva
2. T.D. = Total Depth.
3. Soil types shown ad
Classification Syst





e at Cone Penetrometer

HORIZONTAL SCALE

ATUTE MILES	0		1	2
KILOMETERS	0	1	2	3

rface elevations shown at activity locations are approximate.
al Depth.
s shown adjacent to soil column are based on Unified Soil
ation System (USCS) and are explained in the appendix.

SOIL PROFILE 1-1'
VERIFICATION SITE, BUTLER CDP

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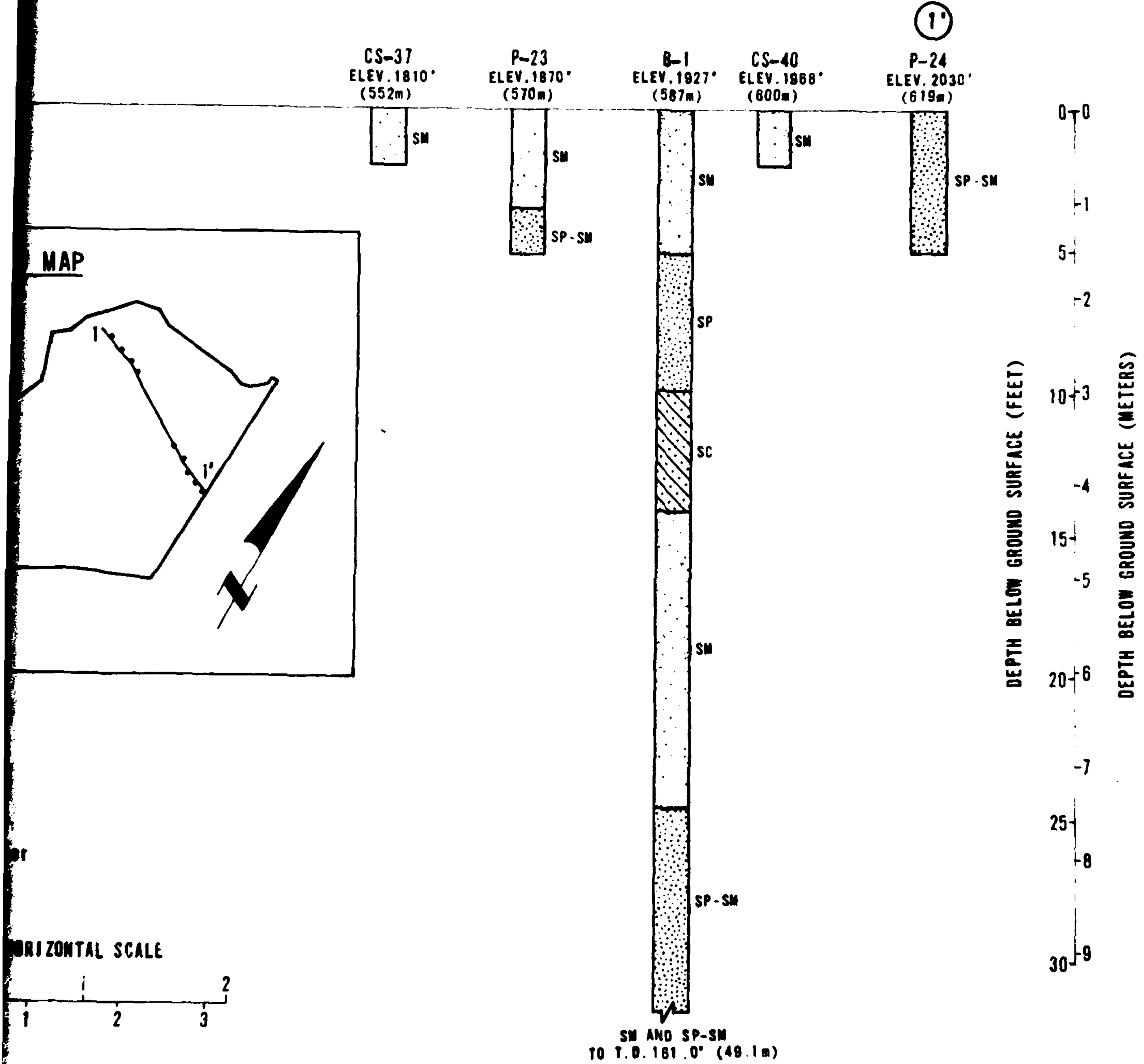


...r

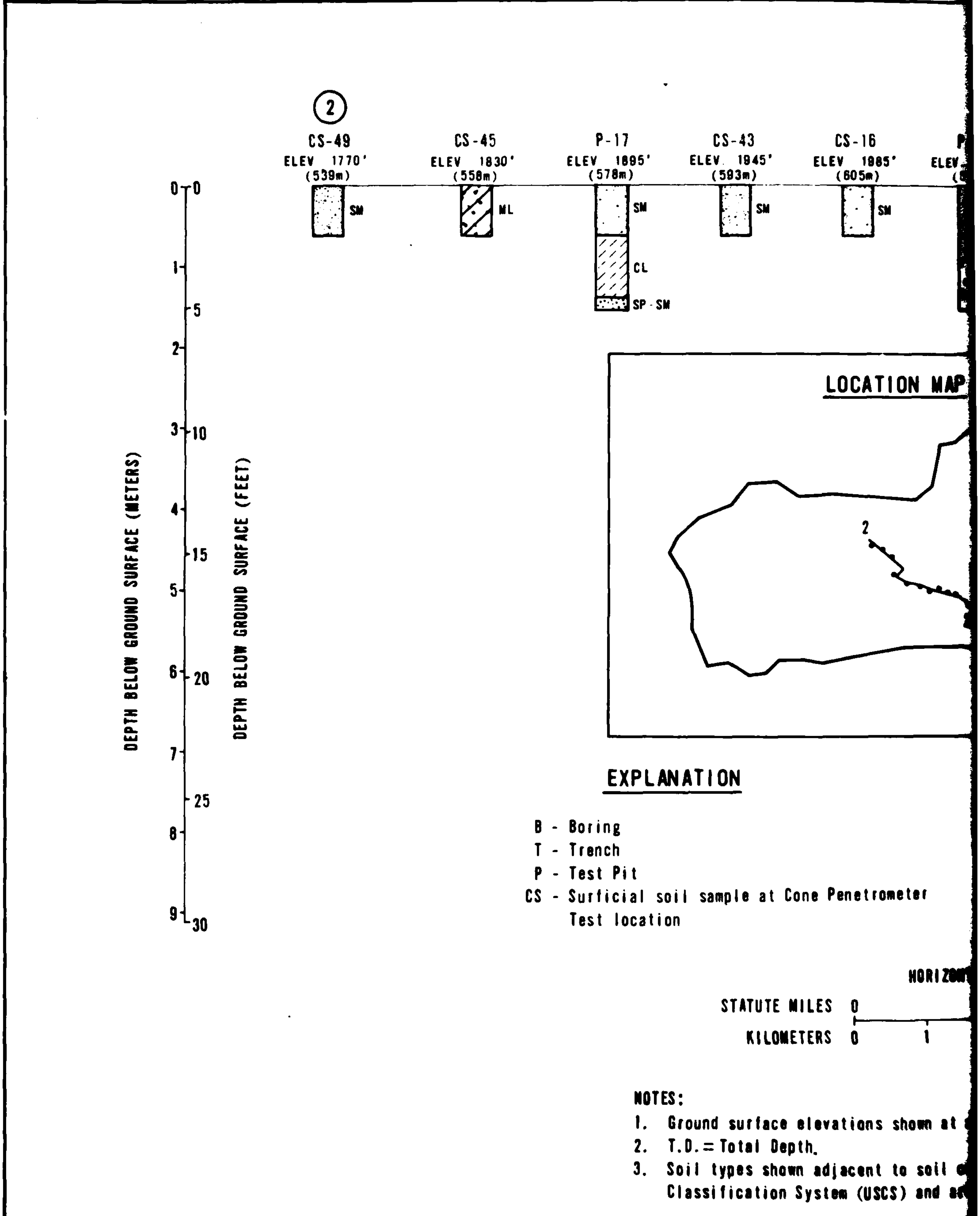
...RIZONTAL SCALE

...m at activity locations are approximate.

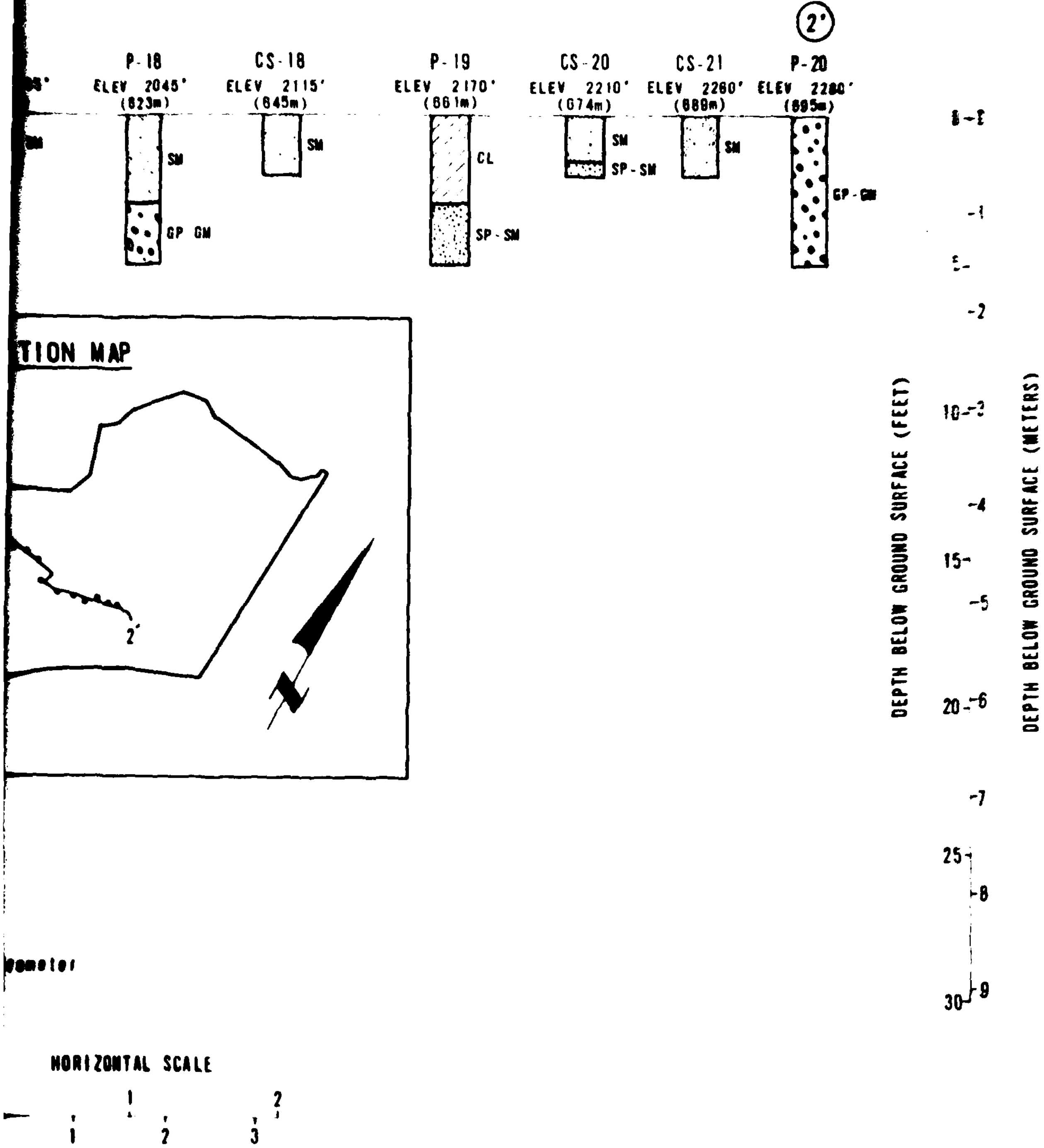
...oil column are based on Unified Soil
...nd are explained in the appendix.

SOIL PROFILE 1-1' VERIFICATION SITE, BUTLER CDP, ARIZONA	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE SAMSO	FIGURE 4-3

FUGRO NATIONAL, INC.


2
CS-49
ELEV 1770'
(539m)
SM
CS-45
ELEV 1830'
(558m)
ML
P-17
ELEV 1895'
(578m)
SM
CL
SP-SM
CS-43
ELEV 1945'
(593m)
SM
CS-16
ELEV 1985'
(605m)
SM
DEPTH BELOW GROUND SURFACE (METERS)
DEPTH BELOW GROUND SURFACE (FEET)
0 1 2 3 4 5 6 7 8 9
0 5 10 15 20 25 30
LOCATION MAP
2
EXPLANATION
B - Boring
T - Trench
P - Test Pit
CS - Surficial soil sample at Cone Penetrometer Test location
STATUTE MILES 0
KILOMETERS 0 1
NOTES:
1. Ground surface elevations shown at
2. T.D. = Total Depth.
3. Soil types shown adjacent to soil
Classification System (USCS) and

- 1



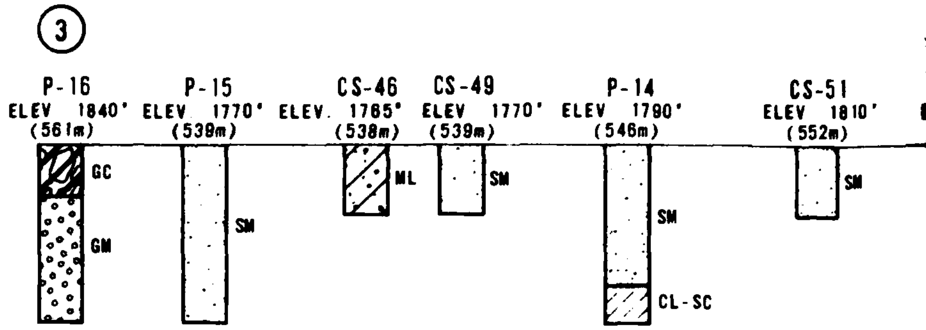
s shown at activity locations are approximate.

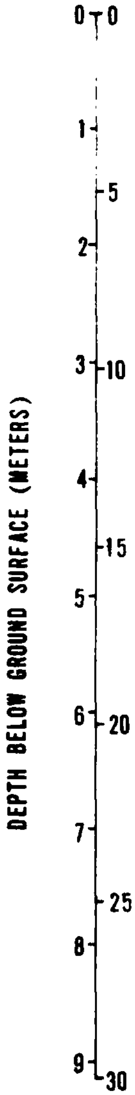
t to soil column are based on Unified Soil
CS) and are explained in the appendix.

SOIL PROFILE 2-2' VERIFICATION SITE, BUTLER CDP, ARIZONA	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	FIGURE 4-4

FUGRO NATIONAL, INC.

2



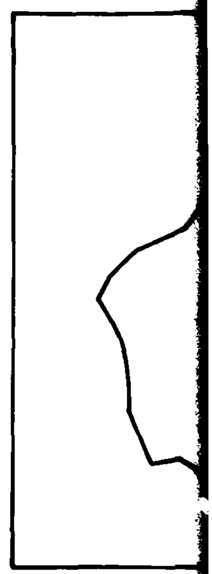


EXPLANATION

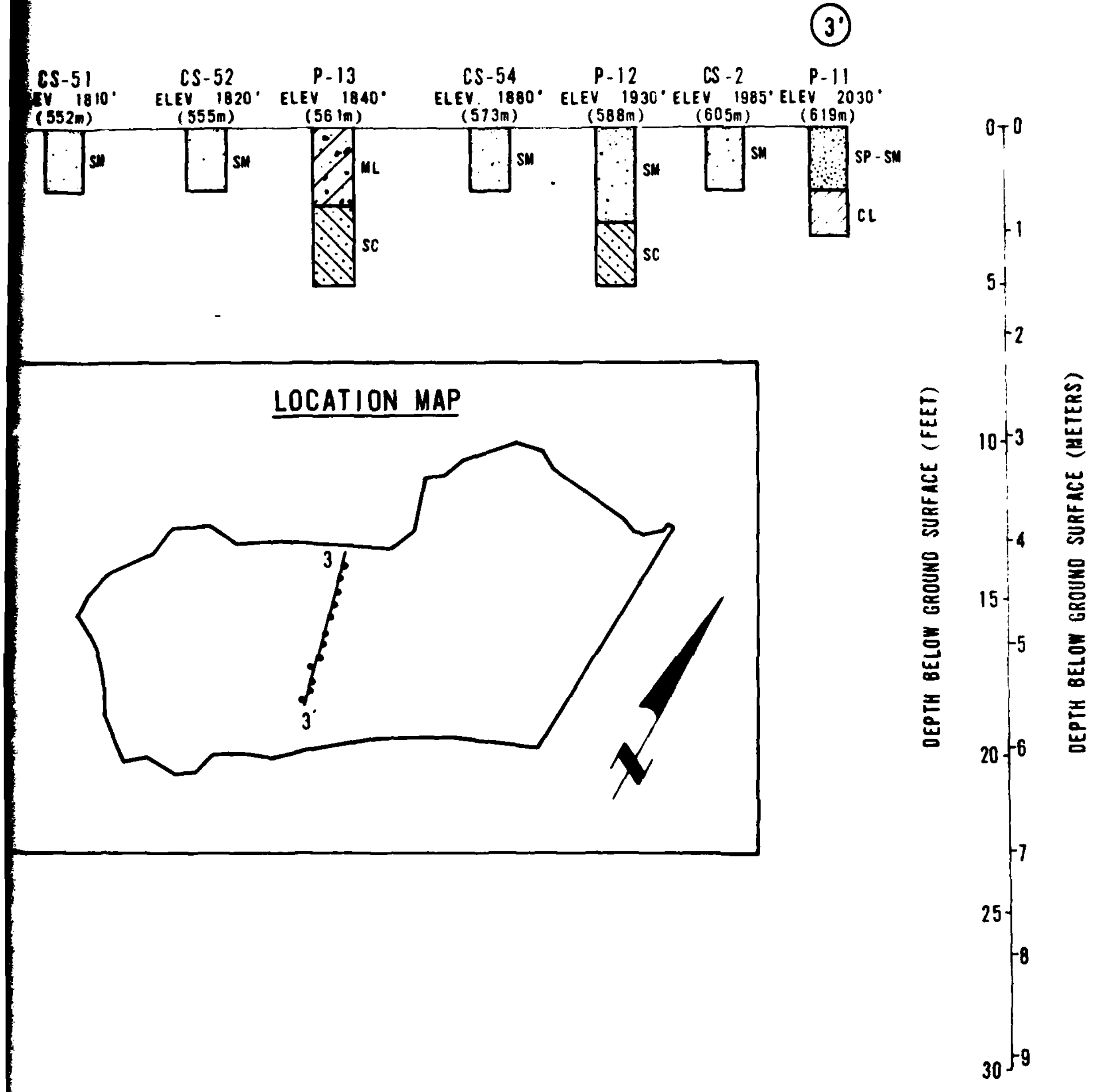
B - Boring
T - Trench
P - Test Pit
CS - Surficial soil sample at Cone Penetrometer Test location

HORIZONTAL SCALE

STATUTE MILES 0 1 2
KILOMETERS 0 1 2 3



NOTES:
1. Ground surface elevations shown at activity locations are app
2. T.D.= Total Depth.
3. Soil types shown adjacent to soil column are based on Unified Classification System (USCS) and are explained in the appendi



...ions are approximate.

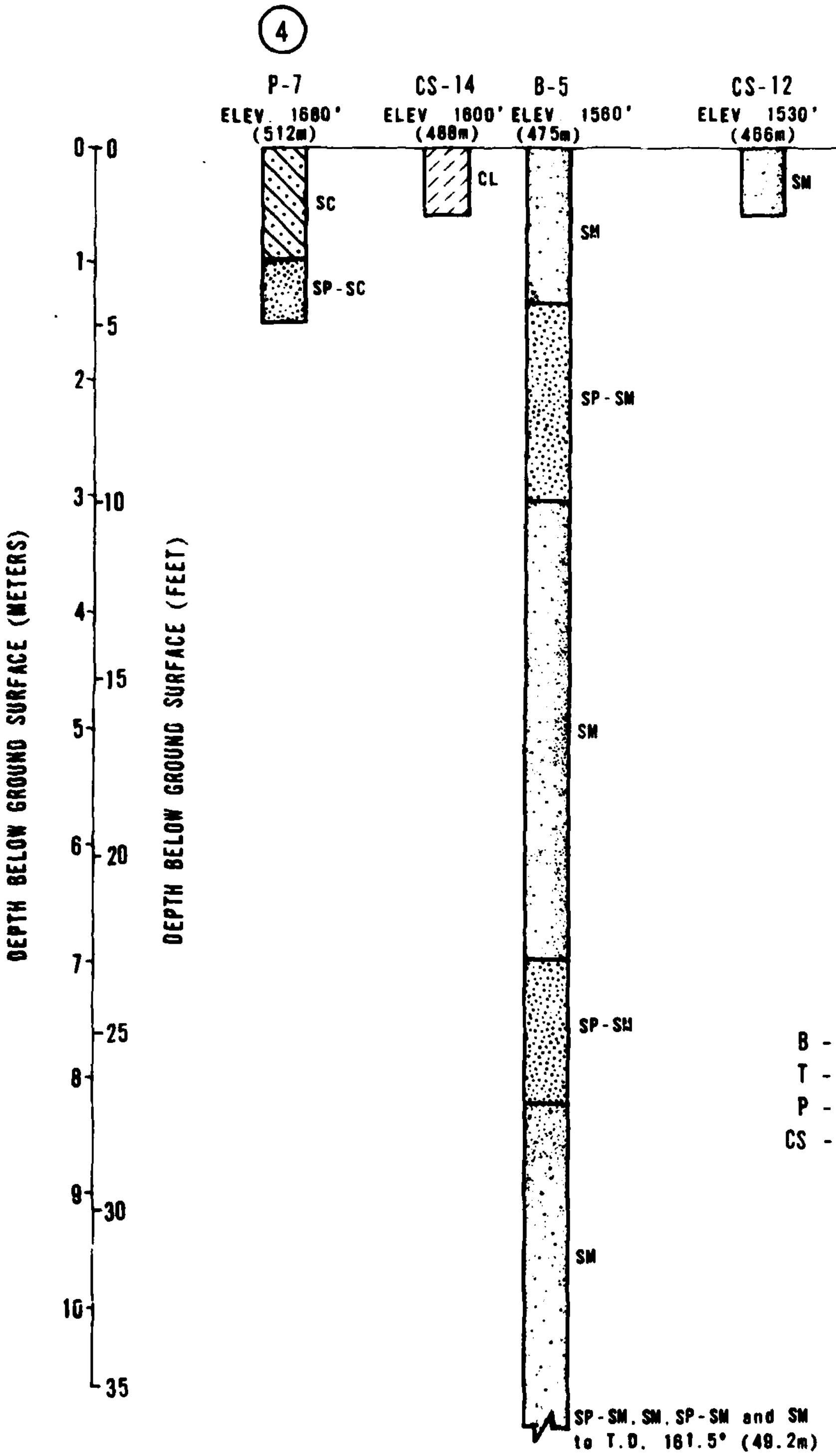
...d on Unified Soil
... the appendix.

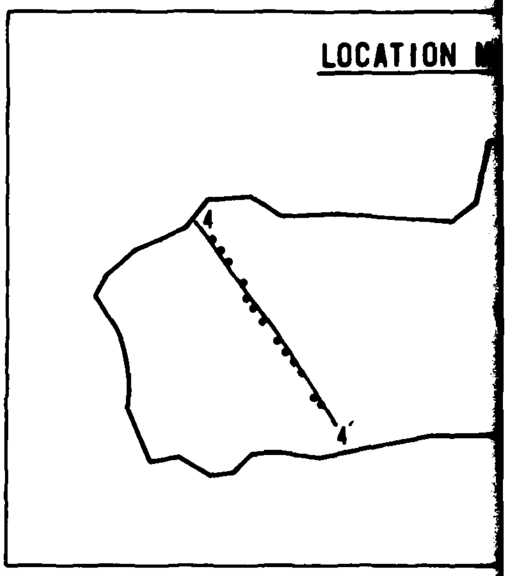
SOIL PROFILE 3-3'
VERIFICATION SITE, BUTLER CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 4-5

FUGRO NATIONAL, INC.





EXPLANATION

B - Boring
T - Trench
P - Test Pit
CS - Surficial soil sample at Cone Penetrometer Test location

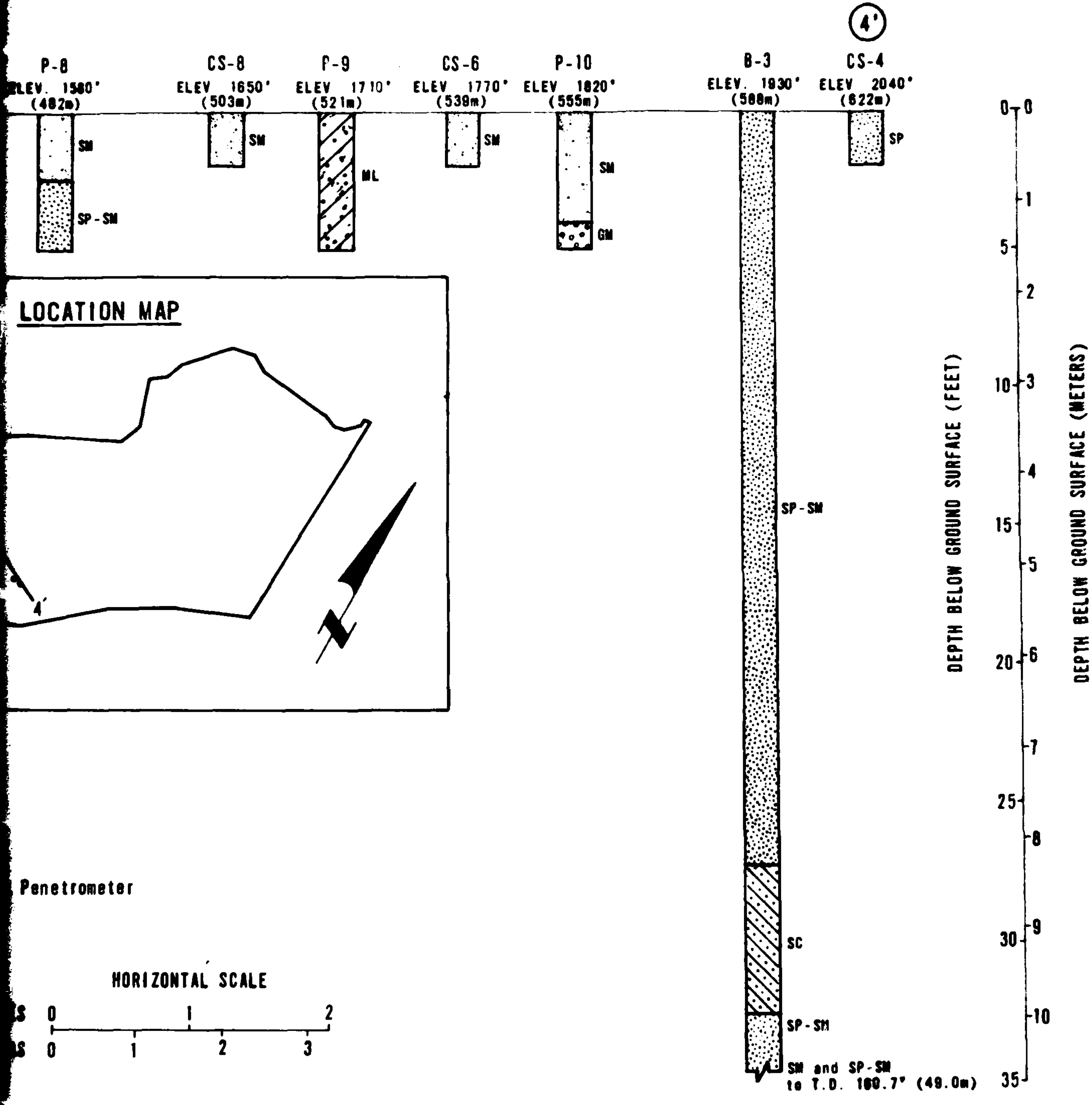
HORI

STATUTE MILES 0

KILOMETERS 0 1

NOTES:

1. Ground surface elevations shown
2. T.D. = Total Depth
3. Soil types shown adjacent to so Classification System (USCS) and



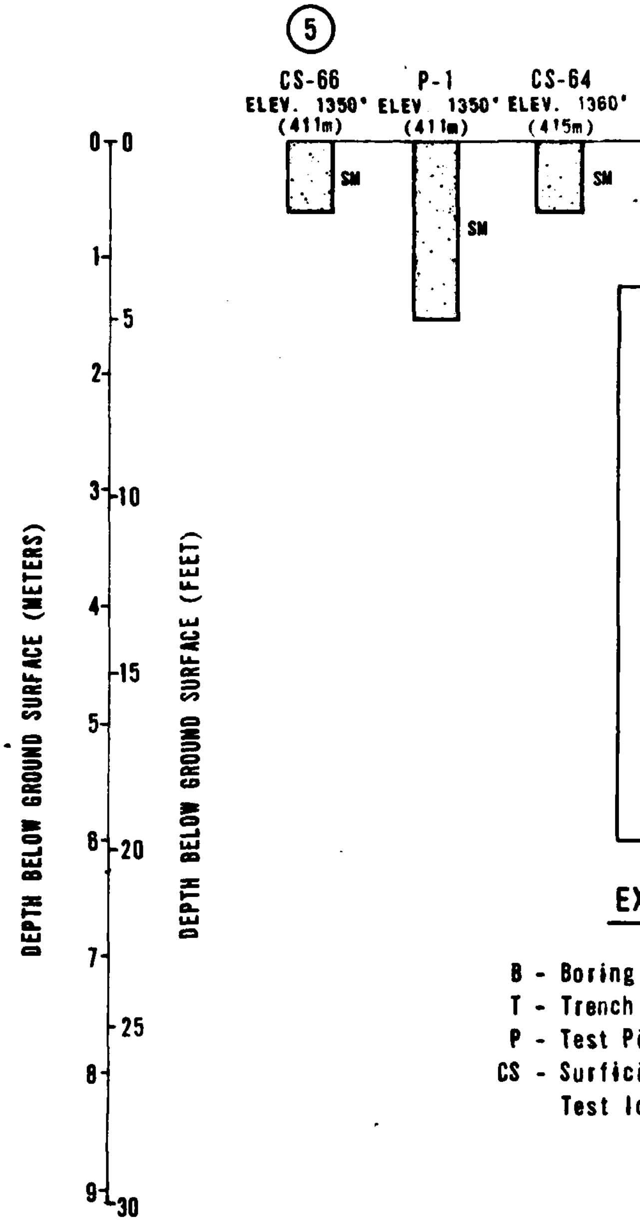
...ations shown at activity locations are approximate.

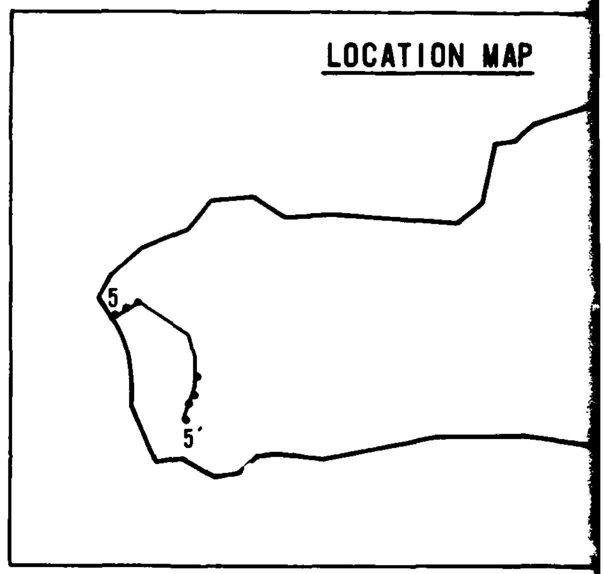
...jacent to soil column are based on Unified Soil ...em (USCS) and are explained in the appendix.

SOIL PROFILE 4-4'
VERIFICATION SITE, BUTLER CDP, ARIZONA

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	FIGURE 4-6

FUGRO NATIONAL, INC.





EXPLANATION

B - Boring
T - Trench
P - Test Pit
CS - Surficial soil sample at Cone Penetrometer Test location

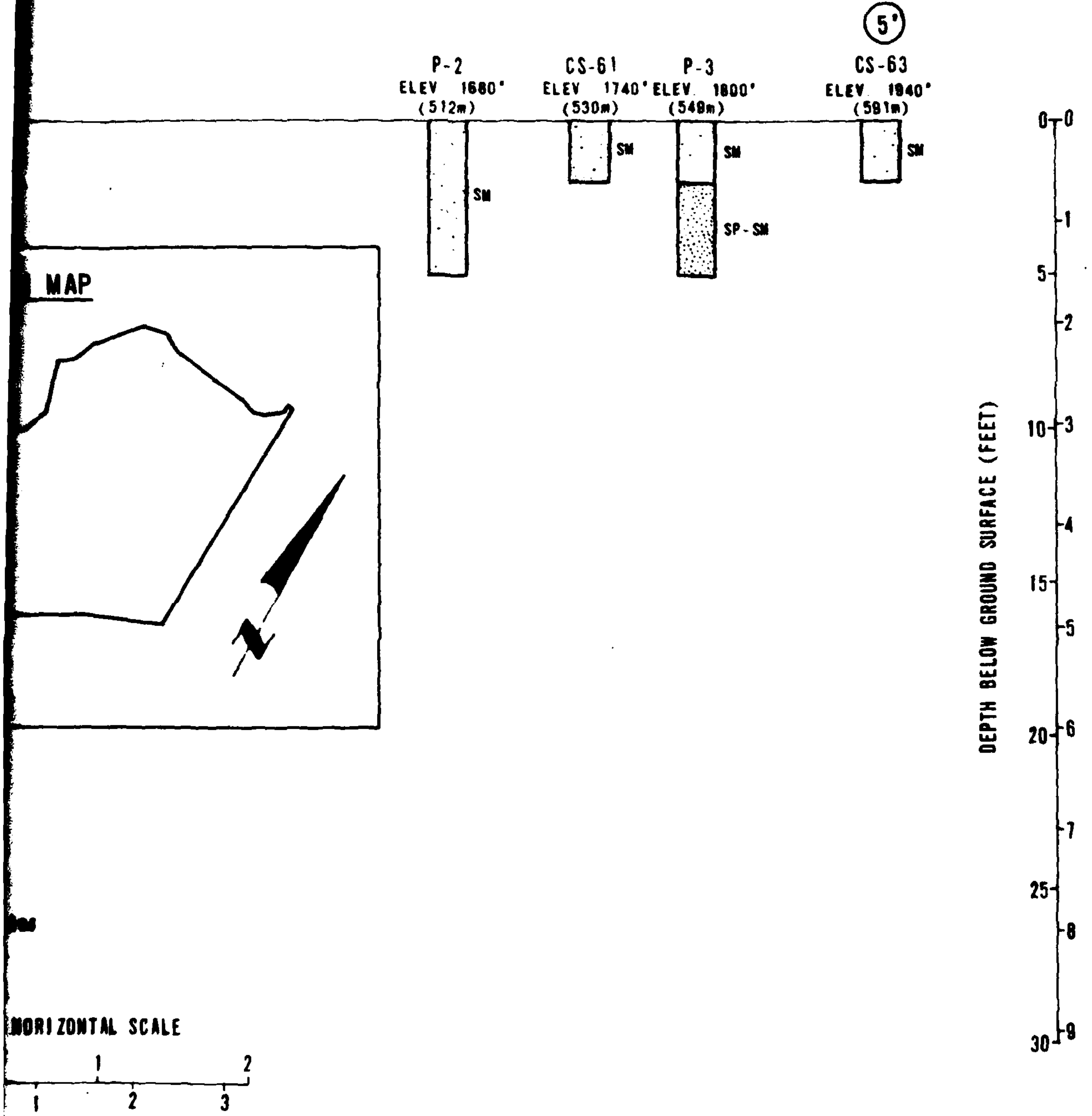
HORIZONTAL S

STATUTE MILES 0 1

KILOMETERS 0 1 2

NOTES:

1. Ground surface elevations shown at acti
2. T.D.= Total Depth.
3. Soil types shown adjacent to soil colum Classifications System (USCS) and are e



...own at activity locations are approximate.

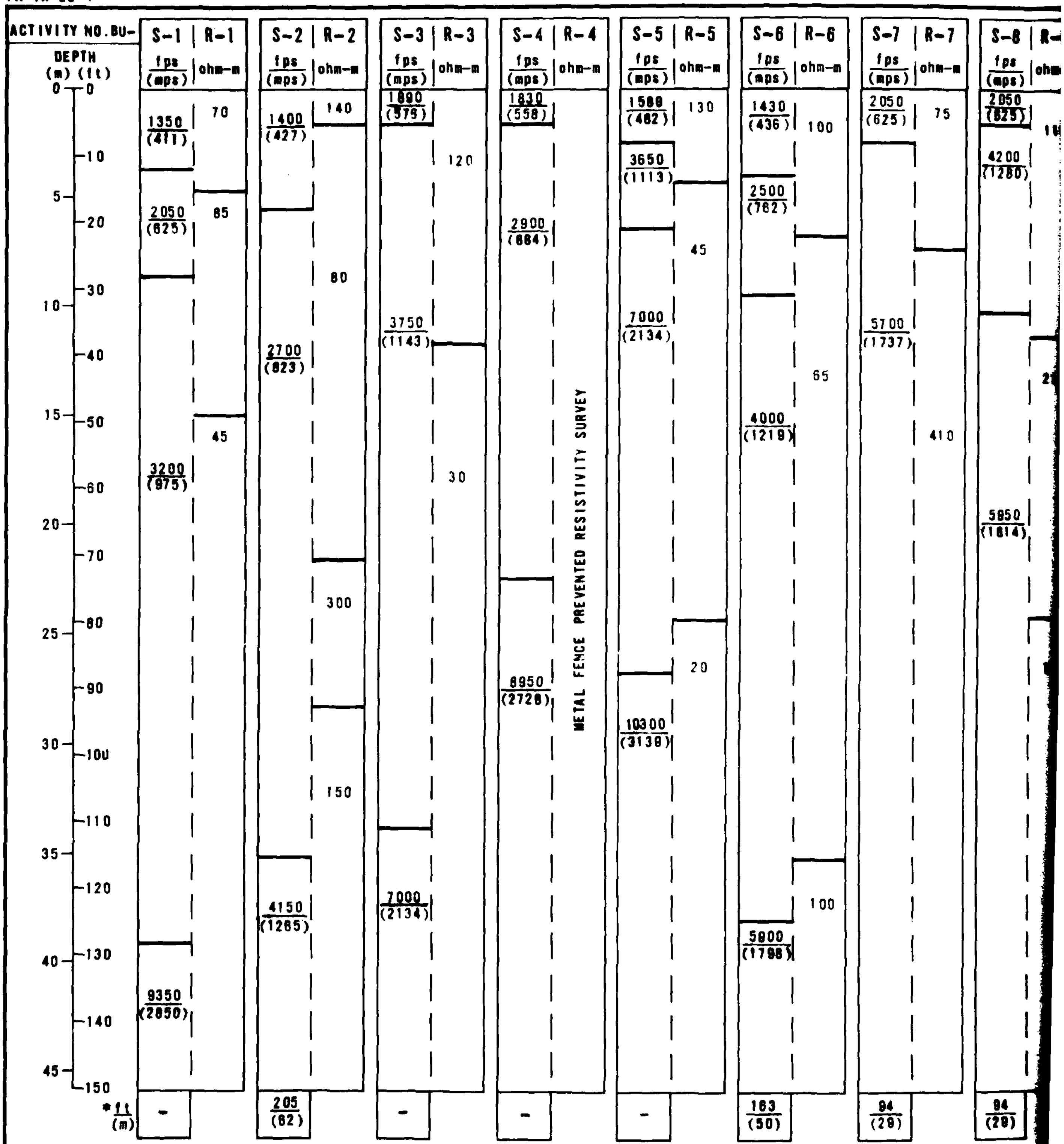
...soil column are based on Unified Soil
...) and are explained in the appendix.

SOIL PROFILE 5-5'
VERIFICATION SITE, BUTLER CDP, ARIZONA

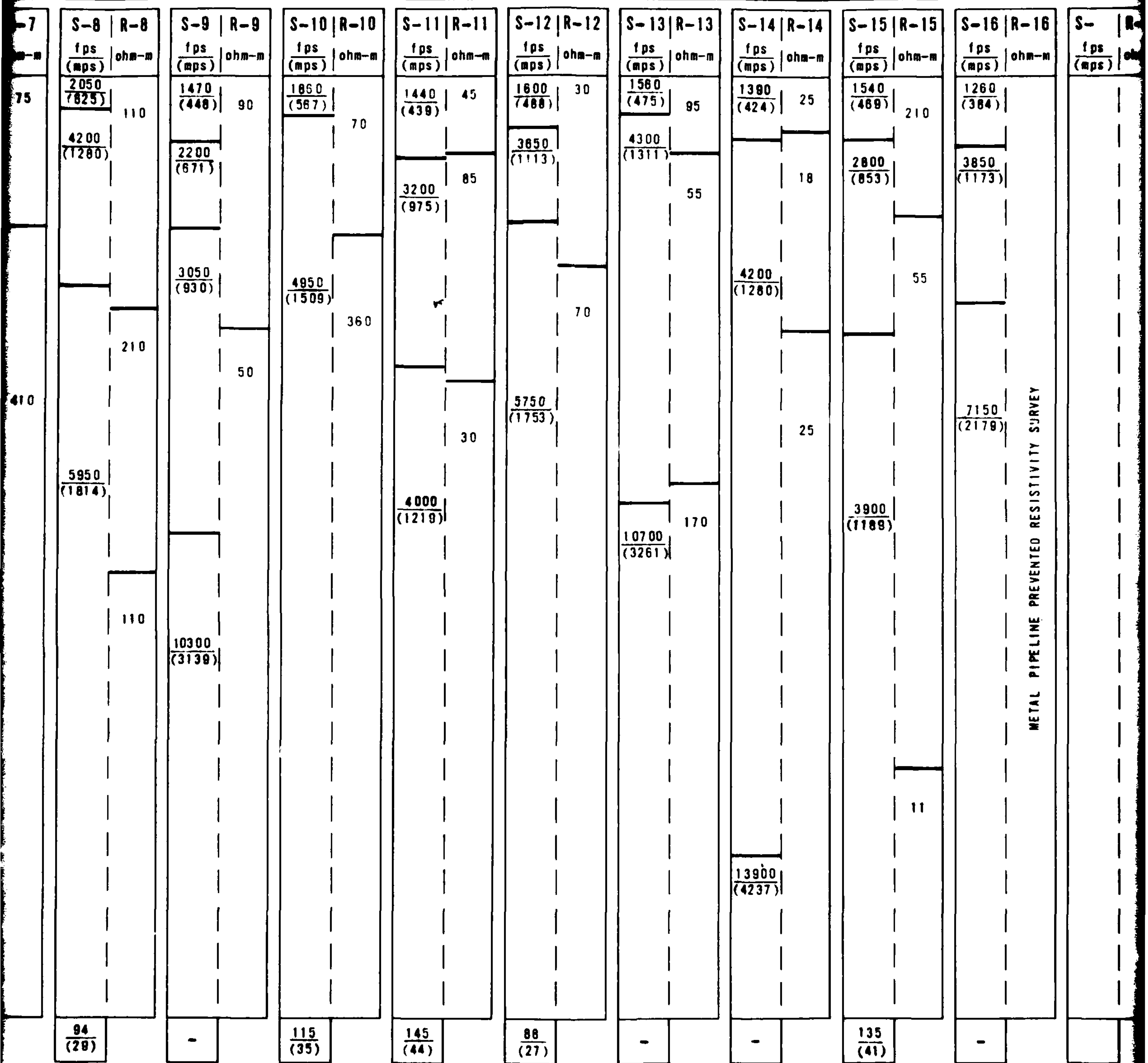
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 4-7

FUGRO NATIONAL, INC.

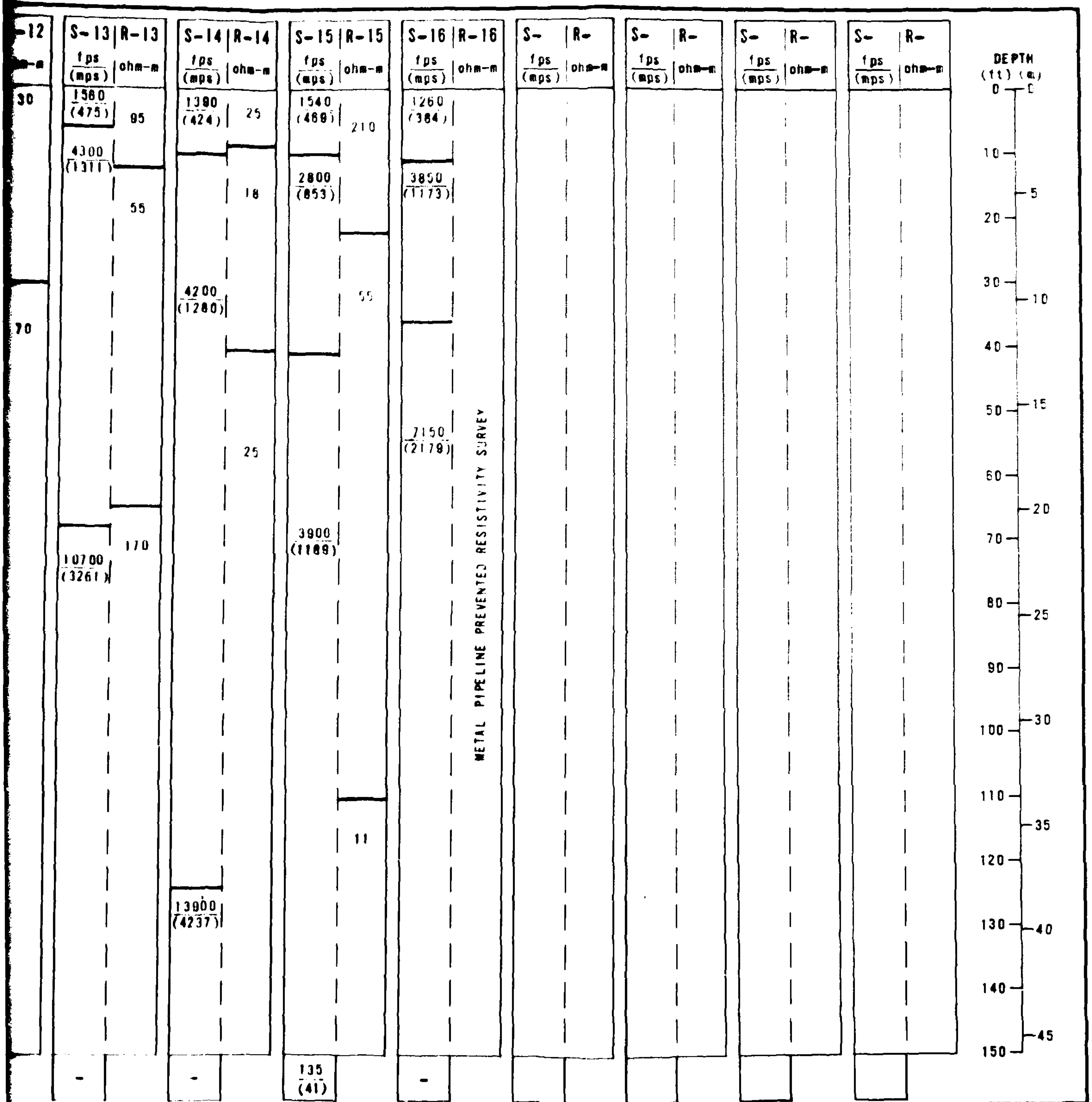


* Approximate depth above which there is no indication of material with a velocity as great as 7000 fps (2134 mps). See Appendix A for an explanation of how this exclusion depth is calculated when the observed velocities are all less then 7000 fps (2134 mps).



S-8 | R-8
fps (mps) | ohm-m
2050 (625) | 110
4200 (1280) | 210
5950 (1814) | 110
94 (29)
S-9 | R-9
fps (mps) | ohm-m
1470 (448) | 90
2200 (671) | 50
3050 (930)
10300 (3139)
-
S-10 | R-10
fps (mps) | ohm-m
1860 (567) | 70
4950 (1509) | 360
115 (35)
S-11 | R-11
fps (mps) | ohm-m
1440 (439) | 45
3200 (975) | 85
4000 (1219) | 30
145 (44)
S-12 | R-12
fps (mps) | ohm-m
1600 (488) | 30
3650 (1113) | 70
5750 (1753)
88 (27)
S-13 | R-13
fps (mps) | ohm-m
1560 (475) | 95
4300 (1311) | 55
10700 (3261) | 170
-
S-14 | R-14
fps (mps) | ohm-m
1390 (424) | 25
4200 (1280) | 18
13900 (4237) | 25
-
S-15 | R-15
fps (mps) | ohm-m
1540 (469) | 210
2800 (853) | 55
3900 (1189) | 11
135 (41)
S-16 | R-16
fps (mps) | ohm-m
1260 (384)
3850 (1173)
7150 (2179)
METAL PIPELINE PREVENTED RESISTIVITY SURVEY
-

- 1



SEISMIC REFRACTION AND
ELECTRICAL RESISTIVITY
VERIFICATION SITE, BUTLER CDP, ARIZONA

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE SAMSO	TABLE 4-4

FUGRO NATIONAL, INC.

AFV-18

3

DEPTH RANGE	2' - 20' (0.6 - 6.0m)		
SOIL DESCRIPTION	Coarse-grained soils		Fi
	Sandy Gravels, Gravelly Sands, Sands, Silty Sands and Clayey Sands		Sandy S
USCS SYMBOLS	GP, GM, SP, SM and SC		ML and C
ESTIMATED EXTENT IN SUBSURFACE %	90-95		5-10
PHYSICAL PROPERTIES			
DRY DENSITY pcf (kg/m^3)	106.2-132.3 (1701-2119)	[19]	93.0-10 (1490-30
MOISTURE CONTENT %	1.2-14.3	[20]	10.6-16.5
DEGREE OF CEMENTATION	none to moderate		none to
COBBLES 3-12 inches (8-30 cm) %	0-10		0
GRAVEL %	1-61	[16]	0-1
SAND %	26-98	[16]	13-49
SILT AND CLAY %	1-46	[16]	50-87
LIQUID LIMIT	42-74	[2]	28
PLASTICITY INDEX	27-46	[2]	15
COMPRESSIONAL WAVE VELOCITY fps (mps)	1260-5700 (384-1137)	[16]	NDA
SHEAR STRENGTH DATA			
UNCONFINED COMPRESSION S_u - ksf (kN/m^2)	NDA		NDA
TRIAXIAL COMPRESSION c - ksf (kN/m^2), $\phi°$	NDA		NDA
DIRECT SHEAR c - ksf (kN/m^2), $\phi°$	C = 0.6-1.4 ϕ = 35-38 (29-67)	[10]	NDA

NOTES:

- Characteristics of soils between 2 and 20 feet (0.6 and 6.0 meters) are based on results of tests on samples from 5 borings, 5 trenches, and 25 test pits, and results of 16 seismic refraction surveys.
- Characteristics of soils below 20 feet (6.0 meters) are based on results of tests on samples from 5 borings and results of 15 seismic refraction surveys.

- [ ]
- NDA -

- 1

– 6.0m)	20' – 160' (6.0 – 49.0m	
Fine-grained soils	Coarse-grained soils	Fine-grained soils
Sandy Silts and Sandy Clays	Gravelly Sands, Sands, Silty Sands, and Clayey Sands	Sandy Silts and Sandy Clays
ML and CL	SW, SP, SM and SC	ML and CL
5 10	90 95	5 10
93 0 100 0 (1490 3091) [3]	96.8 137 0 (1551 2194) [65]	104 3 (167[illegible]) [illegible]
10 6 16 5 [3]	3 3 21 8 [65]	21 5 [illegible]
none to weak	none to moderate	moderate to strong
0	0 10	0
0 1 [4]	0 46 [36]	0 [1]
13 49 [4]	47 93 [36]	30 [1]
50 87 [4]	4 49 [36]	70 [1]
28 [1]	37 46 [2]	36 [1]
15 [1]	18 26 [2]	13 [1]
NDA	2050 5950 (625 1814) [15]	9350 (2850) [1]
NDA	NDA	NDA
NDA	NDA	NDA
NDA	C = 0 1 2 Ø 36 40 (0 57) [15]	NDA

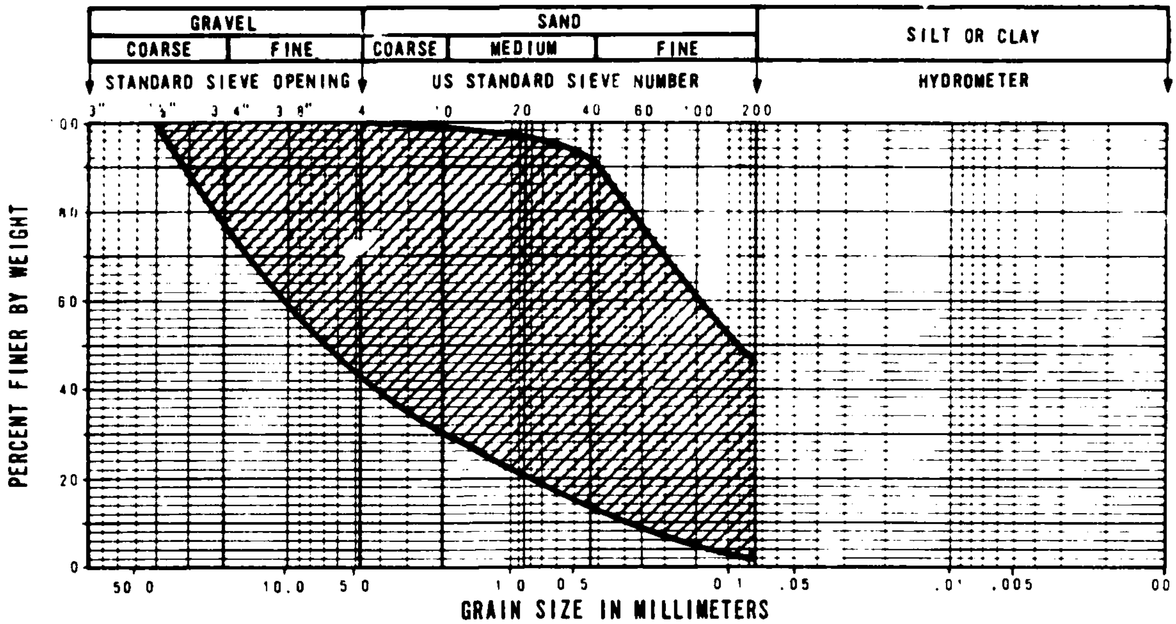
• [ ] – Number of tests performed.
• NDA – No data available (insufficient data or tests not performed.)

CHARACTERISTICS OF SUBSURFACE SOILS VERIFICATION SITE, BUTLER CDP, ARIZONA	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE SAMSO	TABLE 4-5

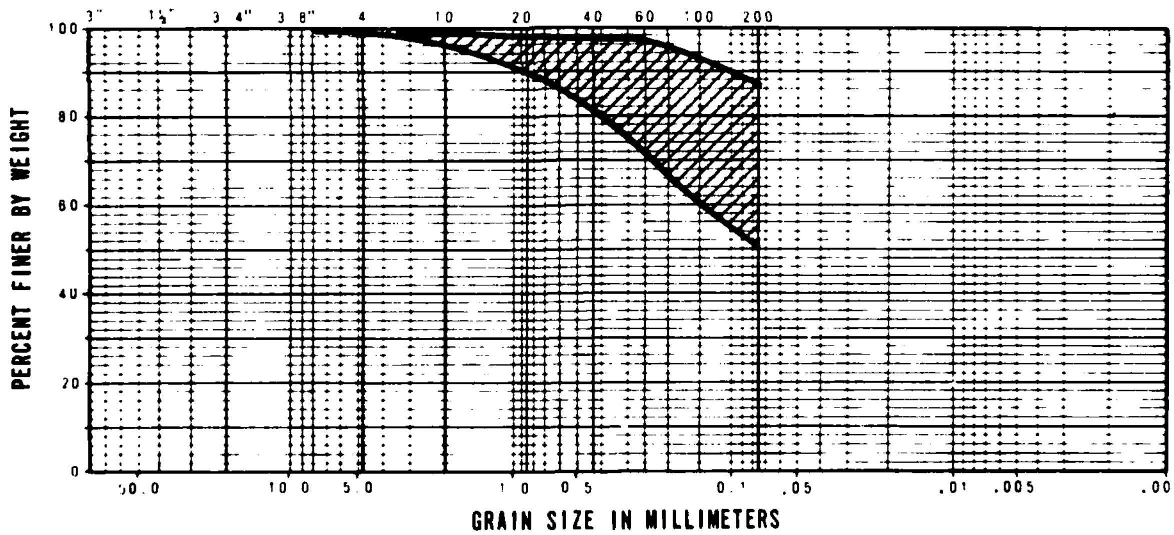
FUGRO NATIONAL, INC.

AFV-20

1 2



SOIL DESCRIPTION: Coarse grained soils from 2 to 20 feet (0.6 to 6m)



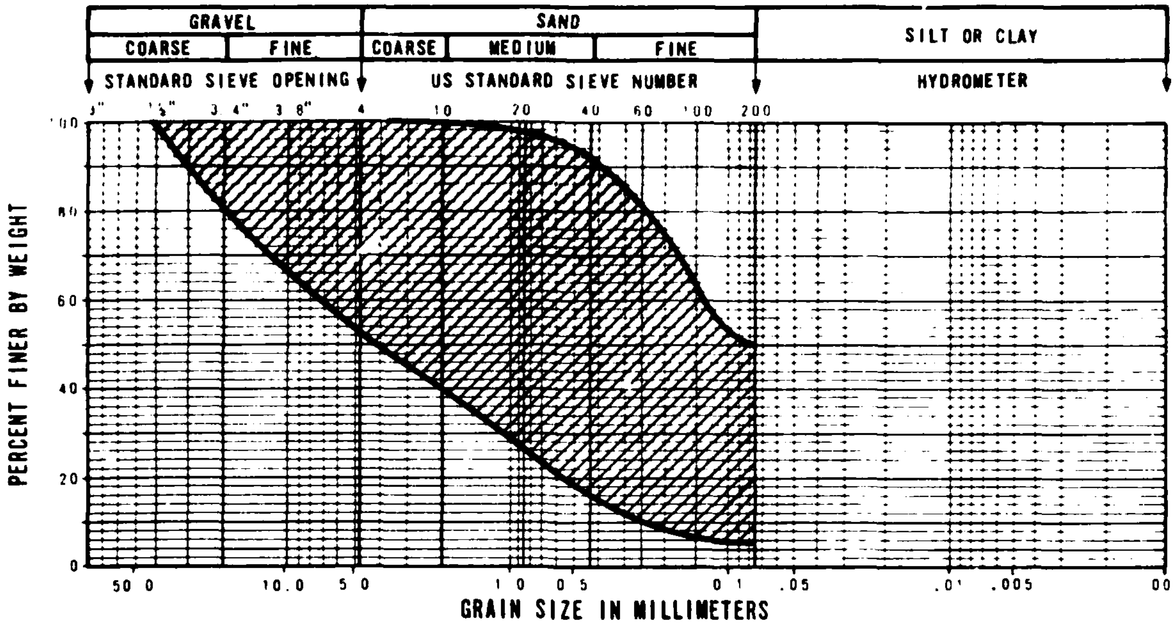
SOIL DESCRIPTION: Fine grained soils from 2 to 20 feet (0.6 to 6m)

RANGE OF GRADATION OF SUBSURFACE SOILS
VERIFICATION SITE, BUTLER CDP, ARIZONA

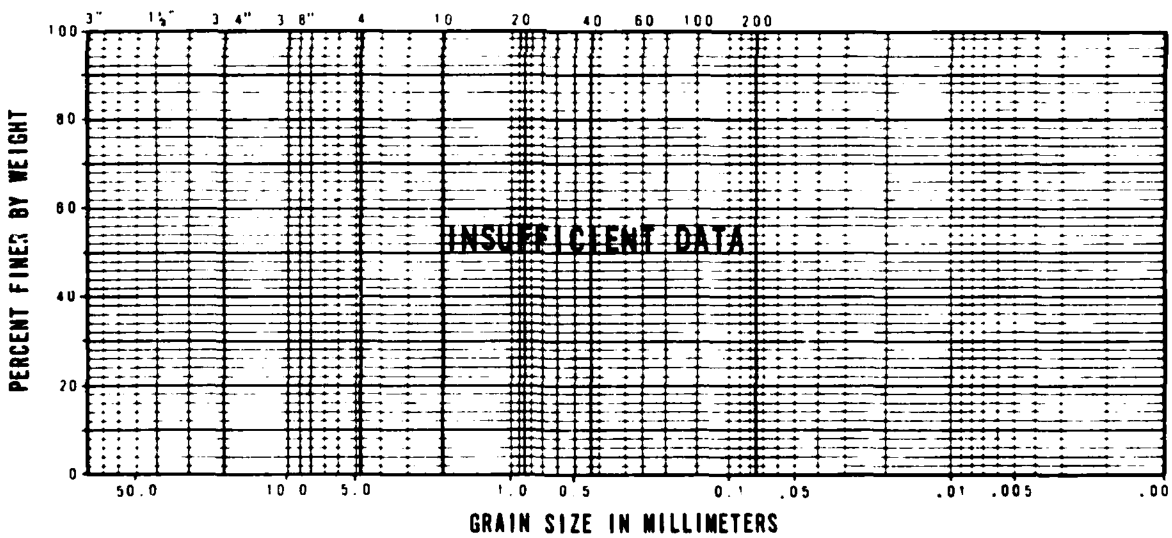
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 4-8
1 OF 2

FUGRO NATIONAL, INC.



SOIL DESCRIPTION: Coarse-grained soils from
20 to 160 feet (6 to 49m)



SOIL DESCRIPTION: Fine-grained soils from
20 to 160 feet (6 to 49m)

RANGE OF GRADATION OF SUBSURFACE SOILS
VERIFICATION SITE, BUTLER CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE
4-8
2 OF 2

FUGRO NATIONAL, INC.

Seismic refraction surveys reveal considerable velocity variation in subsurface soils with no cross valley layers of near uniform velocity apparent below the first (surficial) layer. First-layer seismic wave velocities range between 1260 and 2050 fps (384 and 625 mps) with a layer depth between 5 and 18 feet (2 and 5 m) below the ground surface. Below the first layer, coarse-grained soils have a seismic wave velocity range between 2050 and 5950 fps (625 and 1814 maps). One deep cemented clay layer had a seismic wave velocity of 9350 fps (2850 mps). These variable seismic wave velocities indicate nonuniformity in subsoil density and cementation.

Electrical resistivity profiles for the Butler Site show a generalized profile of three distinct resistivity layers. The middle layer displays higher resistivity than either the upper or lower layers, indicating salt concentration in the upper and lower layers from leaching. Electrical conductivity of the soils in the upper 50 feet (15 m) ranges from 0.0040 to 0.0487 mhos per meter (average 0.0141 mhos per meter). All measured electrical conductivities in the upper 50 feet equaled or exceeded the minimum value of 0.004 mhos per meter specified in the Fine Screening criteria. Chemical test results indicate a negligible to mild potential for sulfate attack of soils on concrete.

4.6 TERRAIN

Terrain conditions are depicted in Drawing 4-3. Categories I through V correspond to younger and intermediate age alluvial

fan deposits. Where stream incision is extreme and topography highly variable, as in the Date Creek area, terrain conditions are unsuitable and have been excluded (category VII). Terrain category VI generally applies to areas of complex and irregular terrain such as dune areas in western Butler.

Drainage in the western part of the site is to the southwest via Cunningham Wash into Ranegras Plain. Elevations along the valley axis range from 2000 feet (610 m) along the south flank of the Little Buckskin Mountain to 1300 feet (397 m) in the extreme southwest at the pass into Ranegras Plain. Drainage in the eastern portion of Butler CDP is to the northwest via Date Creek into the Santa Maria River.

Younger and intermediate alluvial fans (terrain categories I and II), exhibiting incisions generally less than 6 feet (2 m), dominate western Butler Valley. Drainage spacing varies from four to ten drainages per mile and average slope is 2 to 3 percent. Terrain in eastern Butler (Date Creek area) is more variable and approximately 50 percent of the area is unsuitable. Excluded areas are generally highly dissected older lacustrine and older alluvial fan deposits. Stream incision depth and spacing in the remaining suitable area is variable, although slopes are generally less than 5 percent.

4.7 DEPTH TO ROCK

Generalized depth to rock contours are shown in Drawing 4-4. Where no subsurface data were available, contours were drawn by extrapolation from areas with data based on similarities in

geologic conditions. Approximately 3 to 5 percent of the area is underlain by rock less than 150 feet (46 m) deep and an additional 3 to 5 percent by rock less than 50 feet (15 m).

Depth to rock contours are generally close to the mountain fronts everywhere throughout Butler Valley as determined from a projection of the topographic slope. Data indicate that rock dips steeply under alluvial deposits except in valley reentrants where numerous low outcrops are commonly found. Thus, many embayments along the mountain fronts have been excluded based on the probability of rock at less than 50 feet.

4.8 DEPTH TO WATER

Drawing 4-5 shows the approximate configuration of the 150-foot (46-m) depth to water contour in the Butler Site. Data represent water levels in the unconfined alluvial aquifer. Interpretations are based on sparse but current data in Briggs (1969), U.S. Geological Survey (1975 and 1978), Wilkins and Webb (1976), and U.S. Bureau of Reclamation (1978).

Water is present at depths exceeding 150 feet below ground surface throughout most of the site with local occurrences in excess of 700 feet (214 m). Shallow water, between depths of 50 and 150 feet, occurs only in the southwestern part of the site at the pass into Ranegras Plain. This area constitutes less than 5 percent of the site. All available data suggests that there is no appreciable ground water at depth less than 50 feet. It may occur as small isolated pockets of perched

water within the basin-fill deposits. Ground water is used to irrigate farmland in southwestern Butler but otherwise is not utilized.

4.9 RESULTS AND CONCLUSIONS

4.9.1 Suitable Area

Resulting suitable area as defined by FY 79 Verification studies in the Butler Site is shown in Drawing 4-6. The site contains approximately 245 mi^2 (640 km^2) of usable area for a hybrid trench or horizontal shelter basing mode and 225 mi^2 (585 km^2) for a vertical shelter basing mode. These results are significantly different from those reported in previous Intermediate/Fine Screening Studies due chiefly to terrain exclusions in the Date Creek area of eastern Butler. Additional shallow rock and water exclusions did not substantially reduce the total suitable area.

4.9.2 Construction Considerations

In this section, geotechnical factors and conditions which would affect the construction of the MX system in the suitable area are discussed. Both the hybrid trench and vertical shelter basing modes are considered.

4.9.2.1 Grading

Surficial slopes in the Butler Site range from 0 to 5 percent (average about 2 percent), thus requiring minimal preconstruction grading for roads and trenches.

4.9.2.2 Roads

Surficial soils exhibit low strength to an average depth of 4 feet (1.2 m) with a maximum depth approaching 9 feet (2.7 m). The subgrade supporting properties of low-strength, coarse-grained soils are inadequate but can be sufficiently improved by mechanical compaction. Compaction to an approximate depth between 2 and 3 feet (0.6 to 0.9 m) appears necessary with deeper compaction required in about 20 percent of the site. Based on results of laboratory CBR tests, compacted coarse-grained soils will provide fair to very good subgrade support for roads.

Due to the infrequent presence of fine-grained soils in the surficial zone, few roadway sections will be underlain by these soils. Where present, fine-grained soils will probably be inadequate for direct support of roadways. Therefore, required support can be attained by using a select granular subbase layer over the compacted fine-grained soil subgrade. As an alternative, fine-grained soils could be partially or totally removed, depending upon their thickness, and replaced by a sufficient thickness of coarse-grained soil to obtain the required subgrade support.

Coarse, gravelly sands or sandy gravels from intermediate alluvial fan and recent channel deposits will prove suitable as a subbase material when the fines content (passing a No. 200 sieve) is less than 25 percent. Well-graded gravels or gravelly sands with minimal fines may prove acceptable as a source for

processed base course materials, but the extent of such materials is unknown.

In western Butler, incision depths range between 1 and 6 feet (0.3 and 1.8 m) with an average of less than 3 feet (0.9 m) in over 90 percent of the suitable area. Areas with drainage depths exceeding 6 feet are restricted to a very narrow zone around the basin margin. Areas of unsuitalbe terrain and deeply incised major drainages (Date Creek and Santa Maria River) have dissected eastern Butler, leaving only isolated parcels of suitable terrain. Average incision depth in the suitable terrain of eastern Butler is approximately 6 feet (1.8 m) with maximum incision more than 15 feet (4.6 m). Cost of drainage structures would be low in western Butler but moderate to high in eastern Butler.

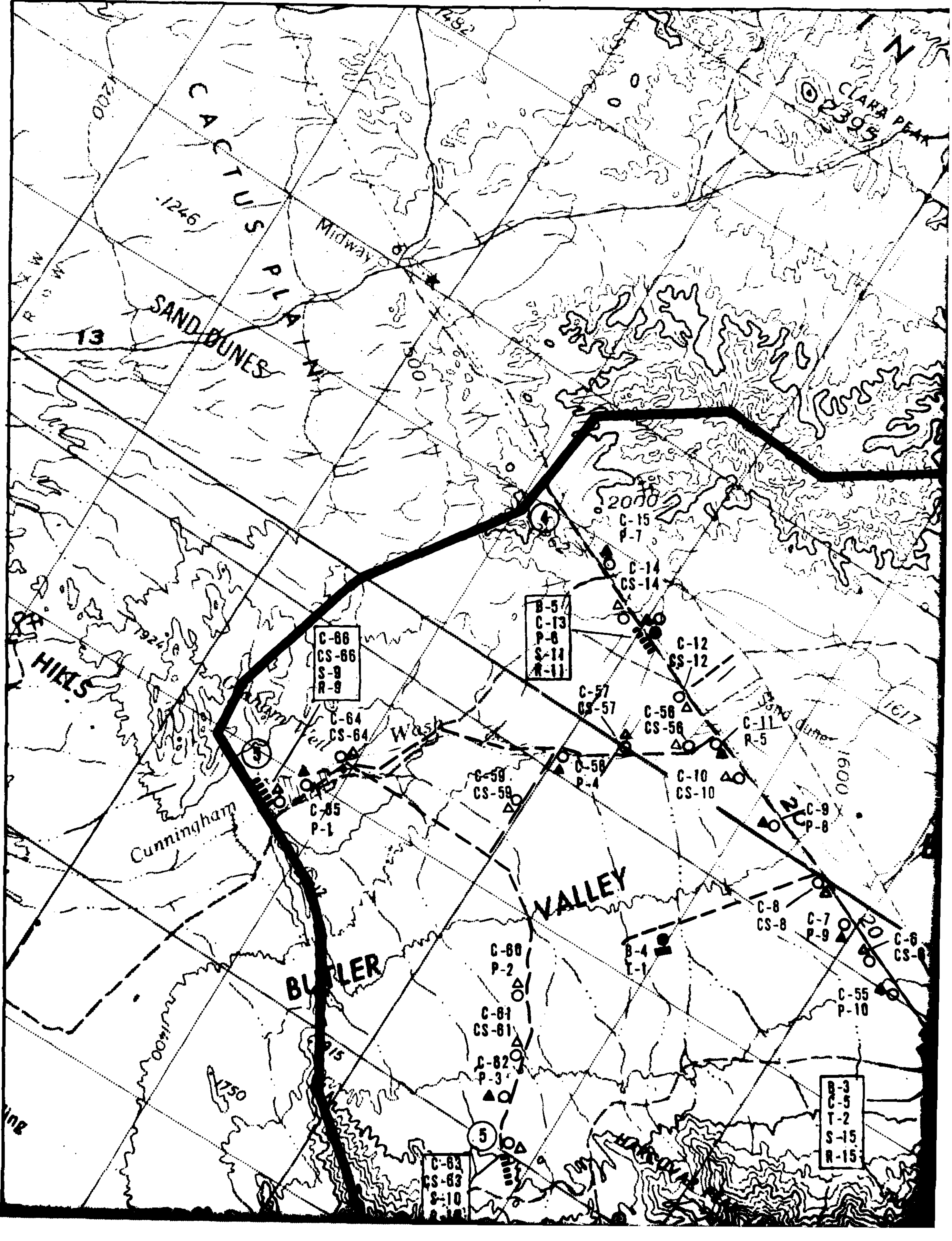
4.9.2.3 Excavatability and Stability

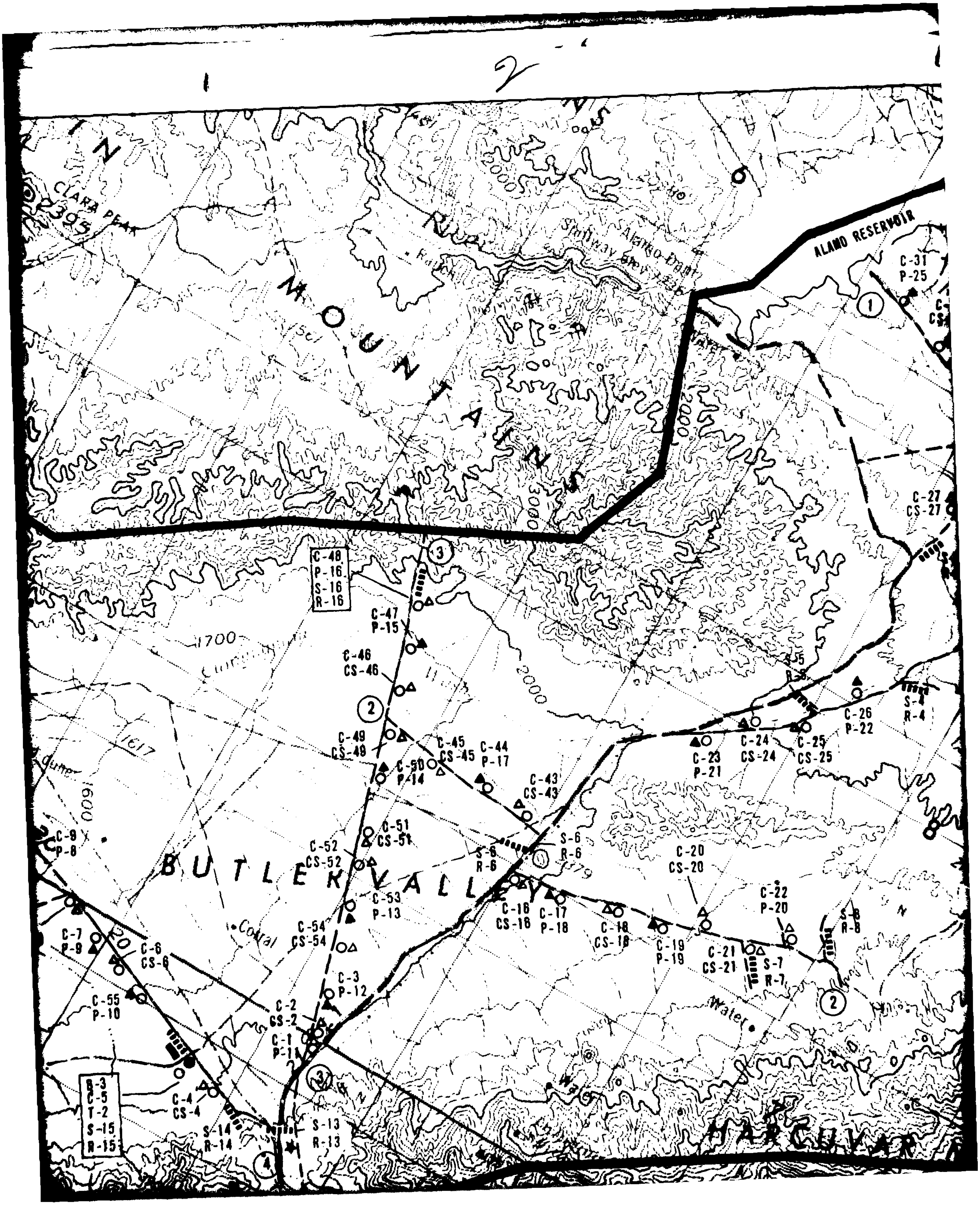
Subsurface soils in the suitable site area are predominantly coarse-grained with fine-grained soils estimated in less than 10 percent of the construction zone. Subsurface soils are generally dense to very dense below 10 feet (3 m), and variable cementation is present in all areas.

Hybrid Trench: Compressional wave velocities in the upper 20 feet (6 m) indicate easy to moderately difficult excavation in most of the suitable area with difficult excavation estimated in approximately 15 percent of the area. MX trenchers could be used to excavate continuous trenches suitable for cast-in-place construction. Because of low-strength surficial soil, the top

2 to 5 feet (0.6 to 1.5 m) in trench excavations will probably have to be sloped back for stability. Below this zone, vertical trench walls are expected to remain temporarily stable in most of the suitable area. In localized remaining areas, the apparent cohesion and/or degree of cementation of the subsurface soils may be inadequate to provide temporary stability for vertical cuts. Therefore, trench walls in these areas will have to be shored or sloped.

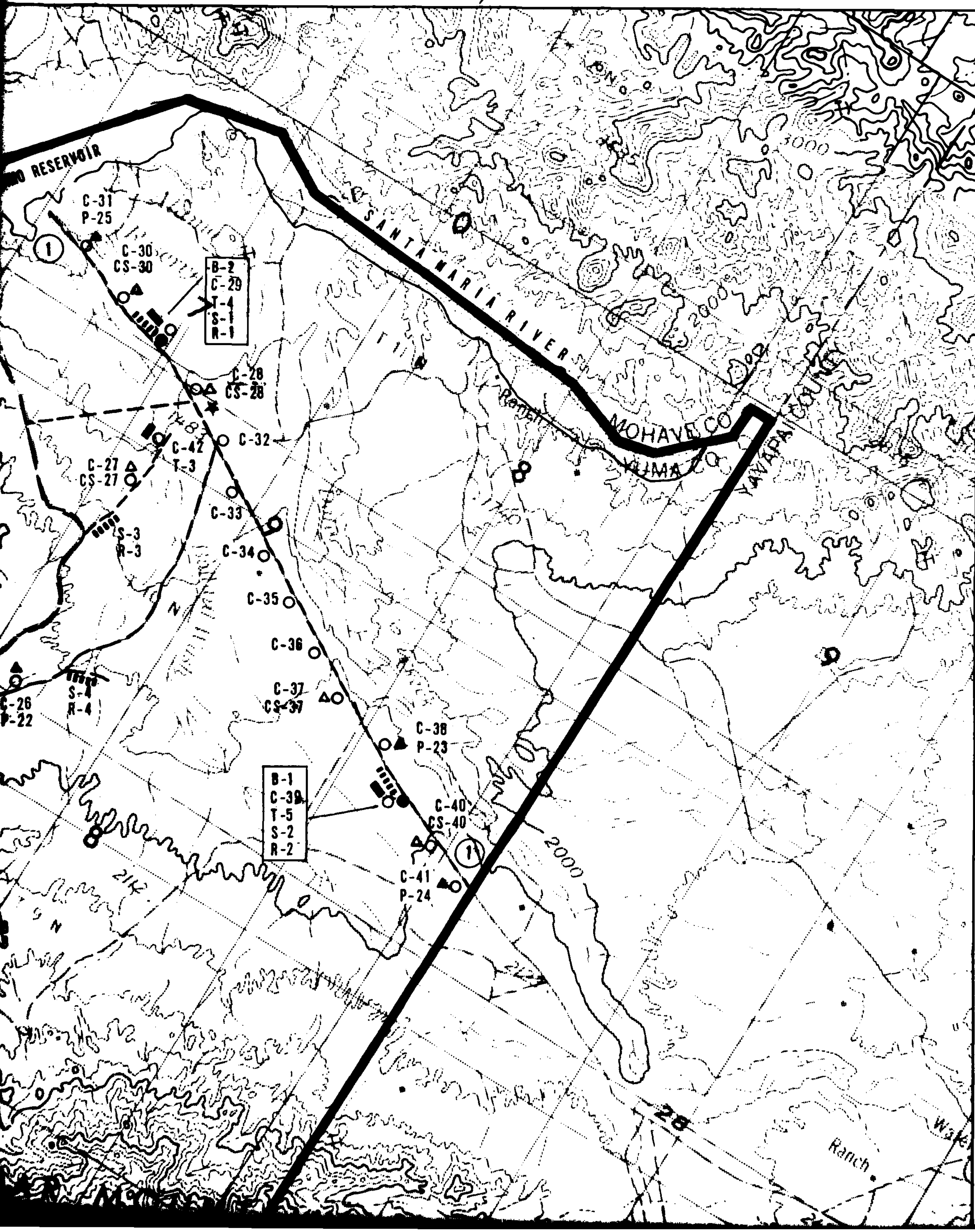
Vertical Shelter: Within the depth of excavation for vertical shelters, results of our investigation indicate that large diameter augers could be used for vertical shelter excavation with difficult excavation expected in approximately 10 percent of the subsurface. Most excavations will be in granular soils with only intermittent cemented or cohesive soil intervals. Vertical shaft walls to depths of 120 feet (37 m) will require shoring or the use of a stabilizing technique.


CACTUS PLAIN
SAND DUNES
Midway
CLARA PEAK
2395
1246
1200
13
HILLS
1924
Cunningham
Wash
VALLEY
BUTLER
2000
1617
1600
1400
1750
Sand dunes
C-15
P-7
C-14
CS-14
B-5
C-13
P-8
S-11
R-11
C-12
CS-12
C-66
CS-66
S-9
R-9
C-64
CS-64
C-57
CS-57
C-56
CS-56
C-11
P-5
C-59
CS-59
C-58
P-4
C-10
CS-10
C-65
P-1
C-9
P-6
C-8
CS-8
C-7
P-9
C-6
B-4
T-1
C-60
P-2
C-55
P-10
C-61
CS-61
C-62
P-3
B-3
C-5
T-2
S-15
R-15
C-63
CS-63
S-10
4
5
20



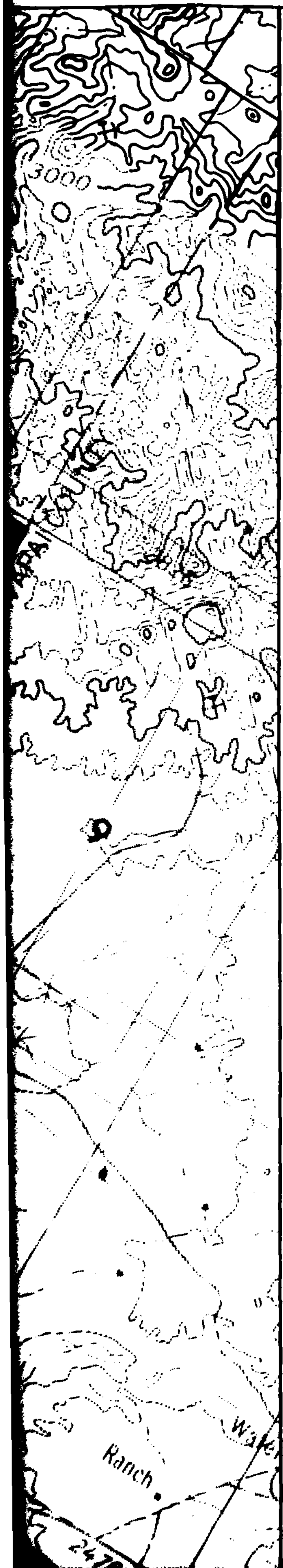
2
MOUNTAINS
CLARA PEAK
2395
Alamo Dam
Spillway Elev 1235
ALAMO RESERVOIR
2000
3000
1700
1600
1617
BUTLER VALLEY
Corral
Water
HARCUVAR
C-31
P-25
C-27
CS-27
C-48
P-16
S-16
R-16
C-47
P-15
C-46
CS-46
C-49
CS-49
C-45
CS-45
C-44
P-17
C-50
P-14
C-43
CS-43
C-51
CS-51
C-52
CS-52
S-6
R-6
C-53
P-13
C-54
CS-54
C-3
P-12
C-2
CS-2
C-1
P-11
S-13
R-13
S-14
R-14
C-4
CS-4
B-3
C-5
T-2
S-15
R-15
C-55
P-10
C-7
P-9
C-6
CS-6
C-9
P-8
C-16
CS-16
C-17
P-18
C-18
CS-18
C-19
P-19
C-20
CS-20
C-21
CS-21
S-7
R-7
C-22
P-20
S-8
R-8
C-23
P-21
C-24
CS-24
C-25
CS-25
C-26
P-22
S-4
R-4
S-5
R-5

1 3 N



RESERVOIR
C-31
P-25
C-30
CS-30
B-2
C-29
T-4
S-1
R-1
C-28
CS-28
C-32
C-42
T-3
C-27
CS-27
S-3
R-3
C-33
C-34
C-35
C-36
C-37
CS-37
C-26
P-22
S-4
R-4
C-38
P-23
B-1
C-39
T-5
S-2
R-2
C-40
CS-40
C-41
P-24
SANTA MARIA RIVER
MOHAVE CO.
YUMA CO.
YAVAPAI COUNTY
3000
2000
Ranch

4



EXPLANATION

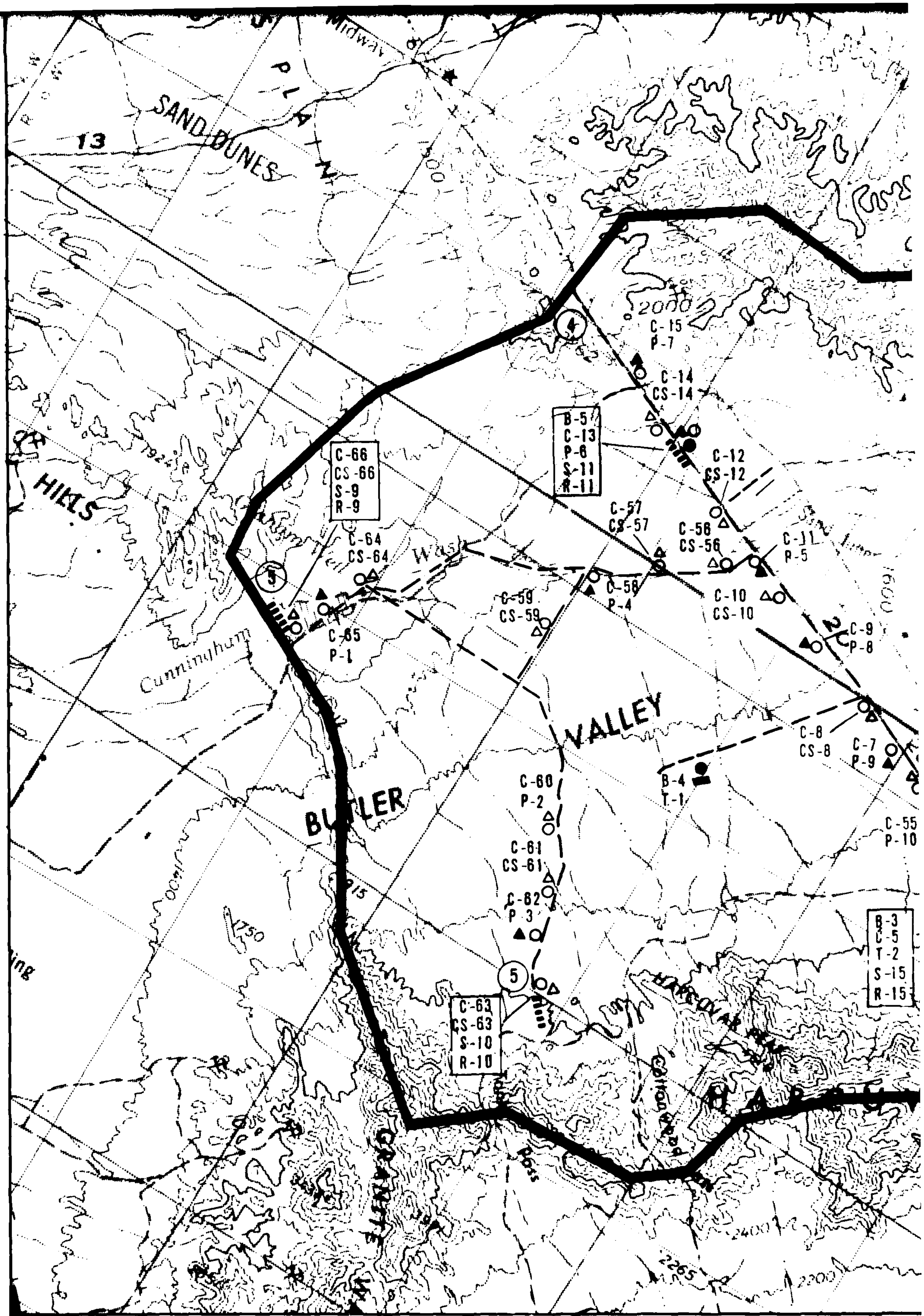
●	B-1	BORING
○	C-1	CONE PENETROMETER TEST (CPT)
△	CS-1	SURFACE SAMPLE AT CPT LOCATION
▬	T-1	TRENCH
▲	P-1	TEST PIT
▪▪▪▪▪	S-1	SEISMIC REFRACTION LINE
	R-1	ELECTRICAL RESISTIVITY LINE
①------①		ACTIVITY LINE

NOTE: Where multiple activities were performed at the same location the correct location is designated by either (1) the boring symbol or (2) the CPT symbol, if no boring was drilled.

SCALE 1;125,000

0 2 4
STATUTE MILES

0 2 4
KILOMETERS

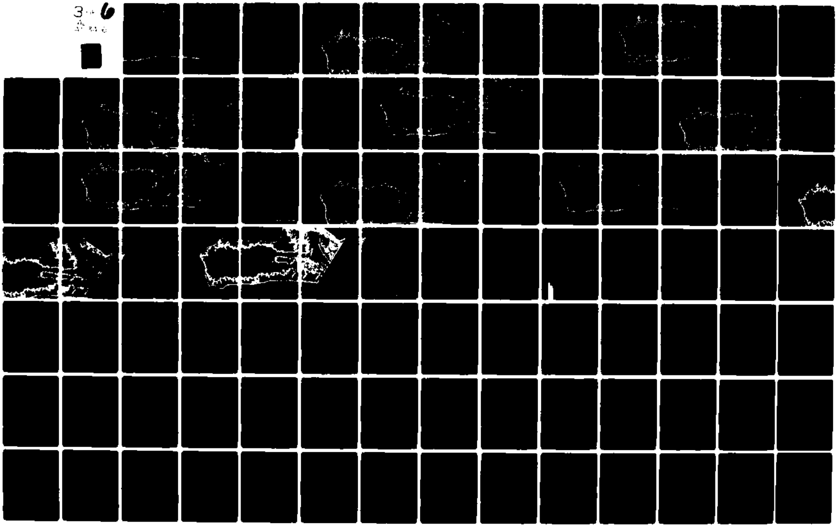


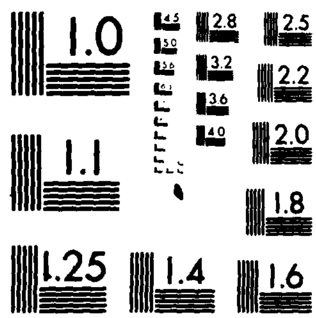
Midway
SAND DUNES
13
HILLS
Cunningham
BUTLER VALLEY
Wash
2000
1750
C-15
P-7
C-14
CS-14
B-5
C-13
P-6
S-11
R-11
C-12
CS-12
C-66
CS-66
S-9
R-9
C-64
CS-64
C-57
CS-57
C-56
CS-56
C-11
P-5
C-58
P-4
C-59
CS-59
C-10
CS-10
C-65
P-1
C-9
P-8
C-8
CS-8
C-7
P-9
B-4
T-1
C-60
P-2
C-55
P-10
C-61
CS-61
C-62
P-3
B-3
C-5
T-2
S-15
R-15
C-63
CS-63
S-10
R-10
4
5
2265
2200
2400

5

AD-A113 416 FUGRO NATIONAL INC LONG BEACH CA F/G 13/2
MX SITING INVESTIGATION. GEOTECHNICAL EVALUATION. VOLUME I. ARI--ETC(U)
NOV 79 F04704-78-C-0027
UNCLASSIFIED FN-TR-28-VOL-1 NL

3 of 6

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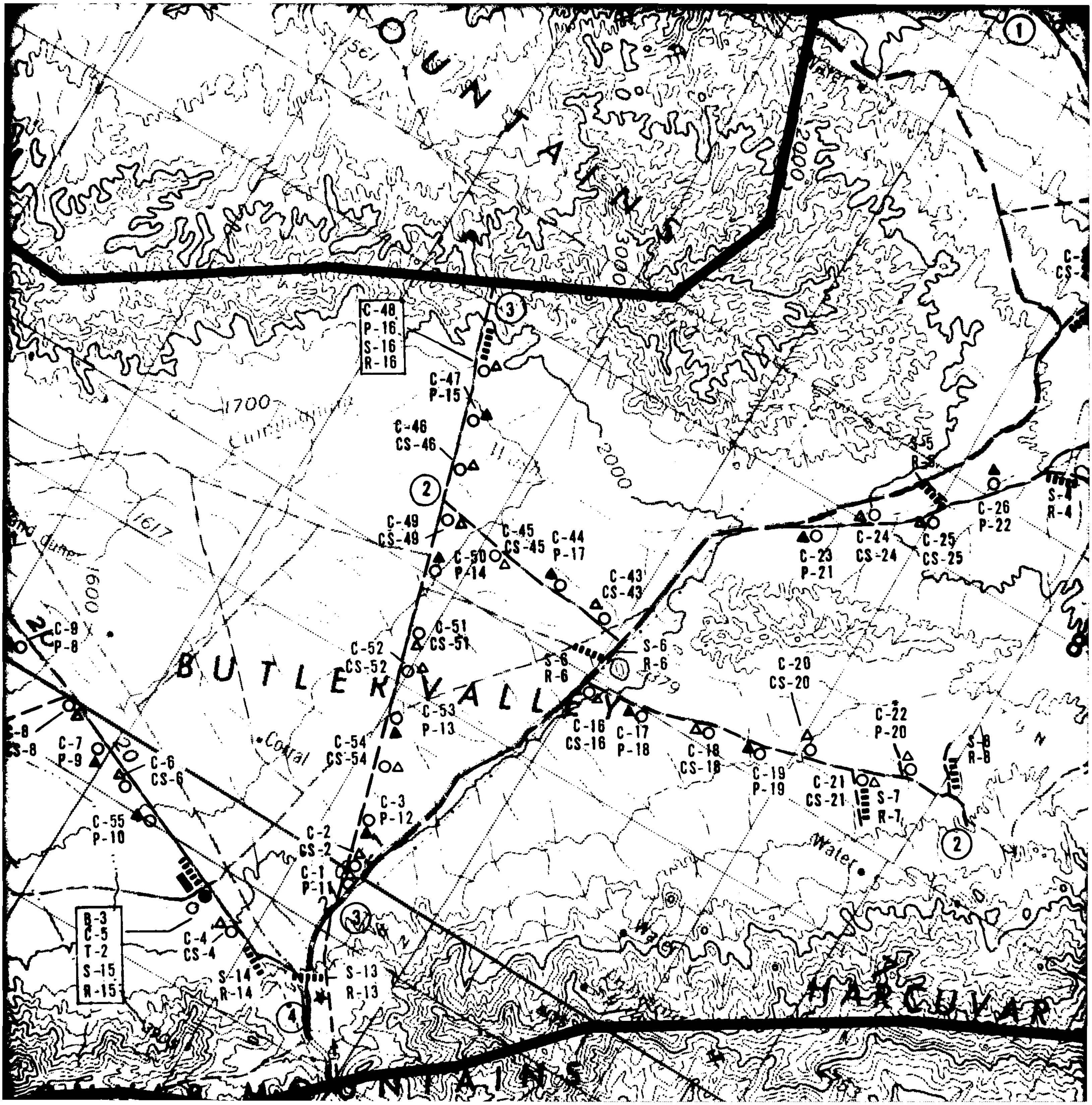
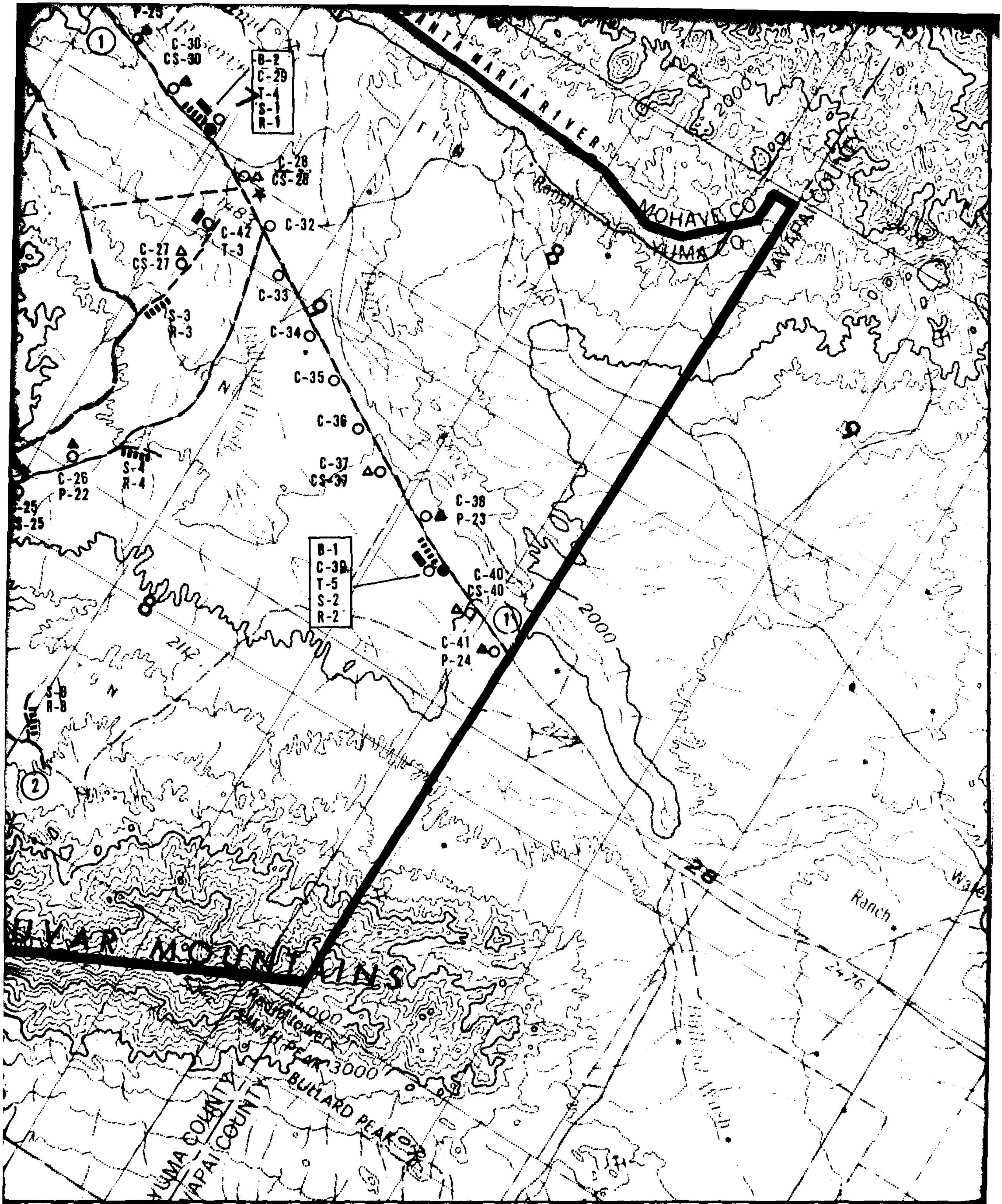
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0


OUNTAINS
BUTLER VALLEY
HARCUVAR
MOUNTAINS
1700
1617
1600
2000
3000
Corral
Water
C-48
P-16
S-16
R-16
C-47
P-15
C-46
CS-46
C-49
CS-49
C-50
P-14
C-45
CS-45
C-44
P-17
C-43
CS-43
C-51
CS-51
C-52
CS-52
S-6
R-6
C-53
P-13
C-54
CS-54
C-3
P-12
C-2
CS-2
C-1
P-11
C-16
CS-16
C-17
P-18
C-18
CS-18
C-19
P-19
C-20
CS-20
C-21
CS-21
S-7
R-7
C-22
P-20
S-8
R-8
C-23
P-21
C-24
CS-24
C-25
CS-25
C-26
P-22
S-5
R-5
S-4
R-4
C-9
P-8
C-8
CS-8
C-7
P-9
C-6
CS-6
C-55
P-10
B-3
C-5
T-2
S-15
R-15
C-4
CS-4
S-14
R-14
S-13
R-13
1
2
3
4


SANTA MARIA RIVER
MOHAVE CO
YUMA CO
YAVAPAI COUNTY
B-2
C-29
T-4
S-1
R-1
C-30
CS-30
C-28
CS-28
C-32
C-42
T-3
C-27
CS-27
C-33
S-3
R-3
C-34
C-35
C-36
C-37
CS-37
C-26
P-22
S-4
R-4
C-38
P-23
B-1
C-39
T-5
S-2
R-2
C-40
CS-40
C-41
P-24
S-B
R-B
2000
Ranch
MOUNTAINS
SMITH PEAK
BULLARD PEAK
YUMA COUNTY
YAVAPAI COUNTY
Ranch
2476
3000
4000

EXPLANATION

● B-1 BORING

○ C-1 CONE PENETROMETER TEST (CPT)

△ CS-1 SURFACE SAMPLE AT CPT LOCATION

▬ T-1 TRENCH

▲ P-1 TEST PIT

S-1 SEISMIC REFRACTION LINE

R-1 ELECTRICAL RESISTIVITY LINE

(1)------(1') ACTIVITY LINE

NOTE: Where multiple activities were performed at the same location the correct location is designated by either (1) the boring symbol or (2) the CPT symbol, if no boring was drilled.

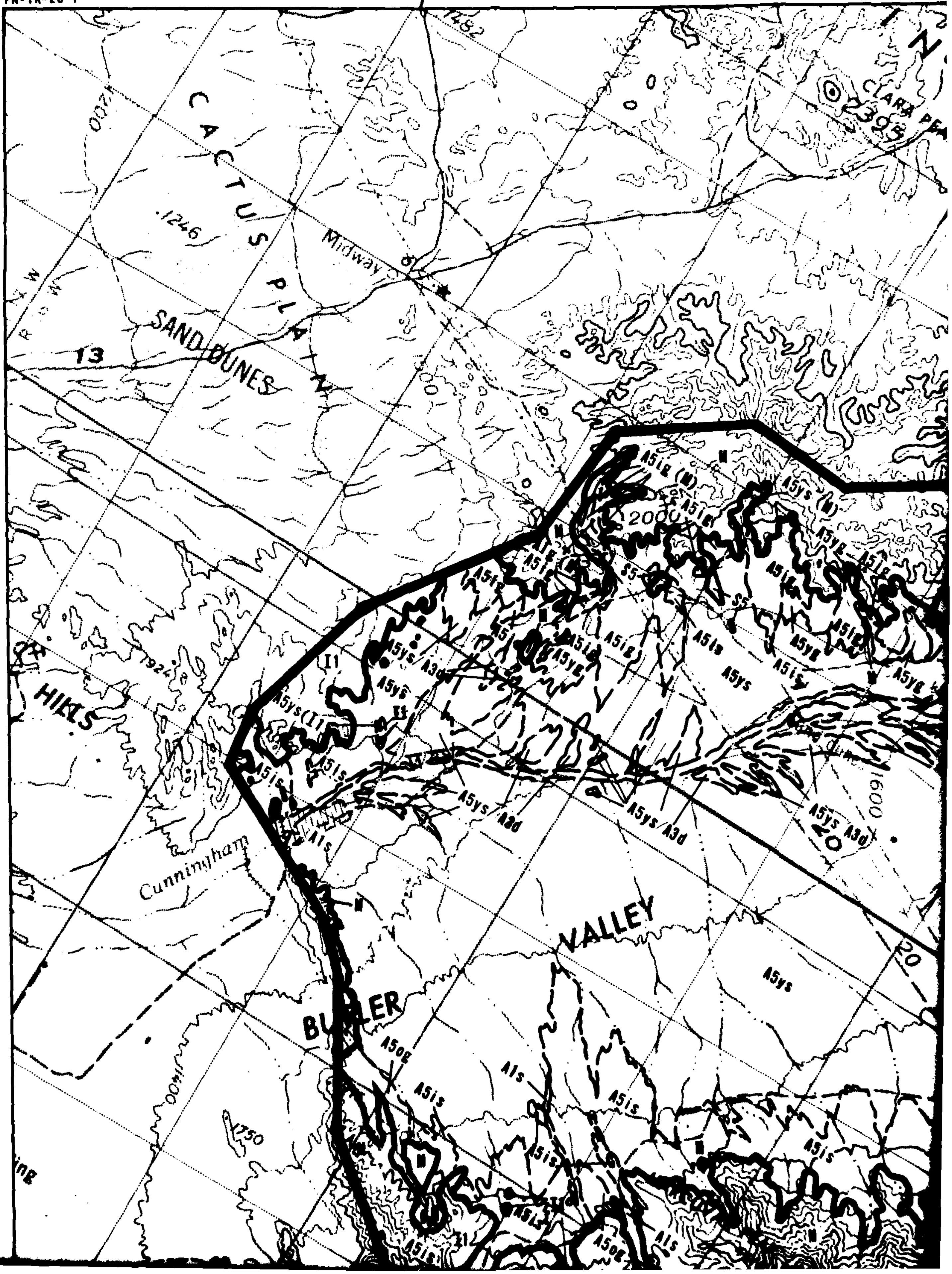
SCALE 1;125,000

0 2
STATUTE MILES

0 2 4
KILOMETERS

ACTIVITY LOCATIONS VERIFICATION SITE, BUTLER CDP, ARIZONA	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	DRAWING 4-1

FUGRO NATIONAL, INC.

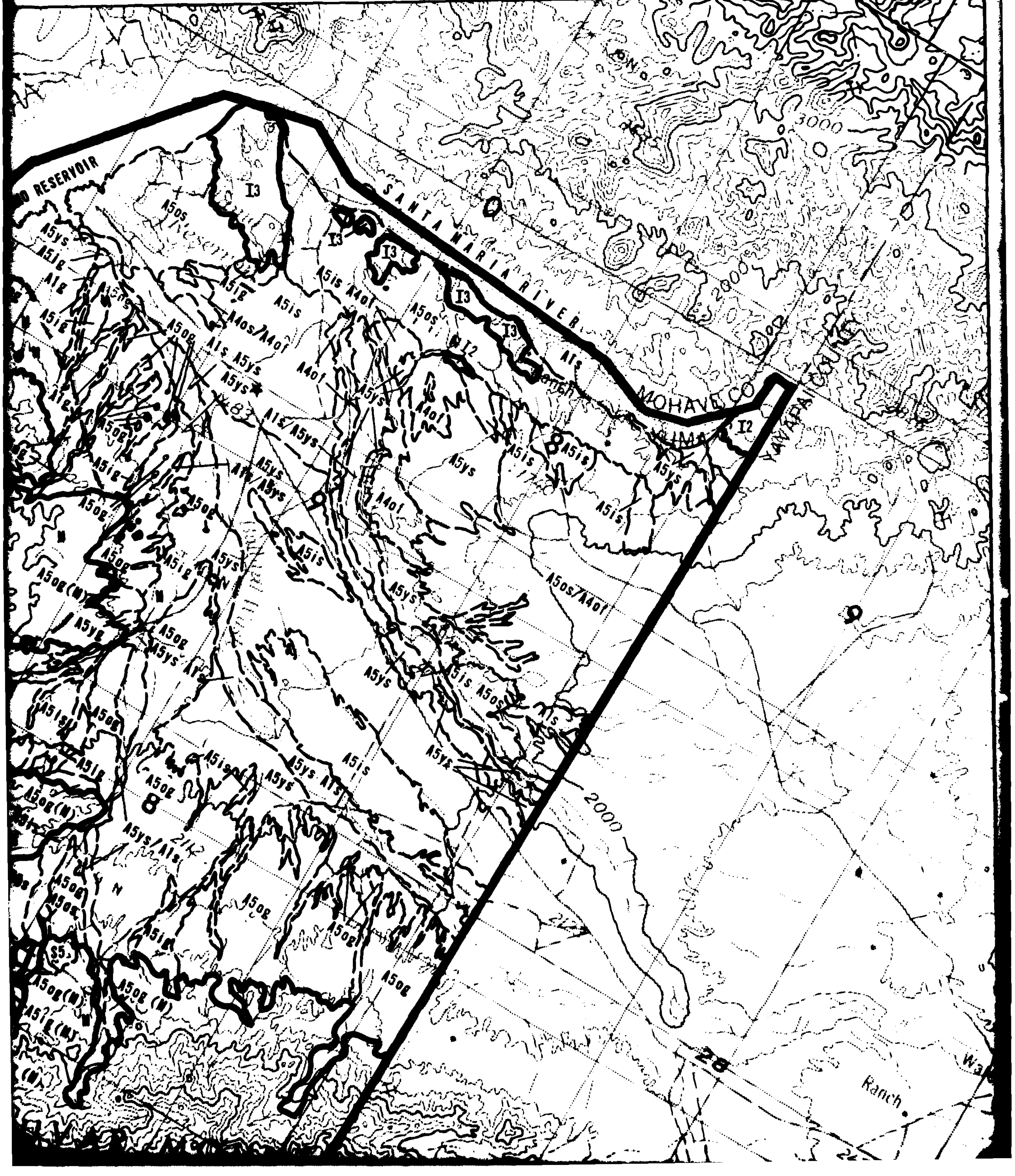

CACTUS PLAIN
SAND DUNES
Midway
CLARA PEAK
2398
1282
1246
13
HILLS
1924
Cunningham
BUTLER VALLEY
1400
1750
1600
A5ig (M)
A5ys (M)
A5ig
A5yg
A5fg
A5is
A5ys
A5ys/A3d
A5ys (I1)
A1s
A5og
2000
S5
I1
20
40


MOUNTAINS
CLARA PEAK
ALAMO RESERVOIR
Alamo Dam
Spillway
BUTLER VALLEY
Corral
A5ys
A5ig
A5yg
A5is
A5og
A5os
A1s
A1g
A3d
A5og (M)
A5ig (M)
A5ys/A1s
S5
I1
M
2000
3000

1

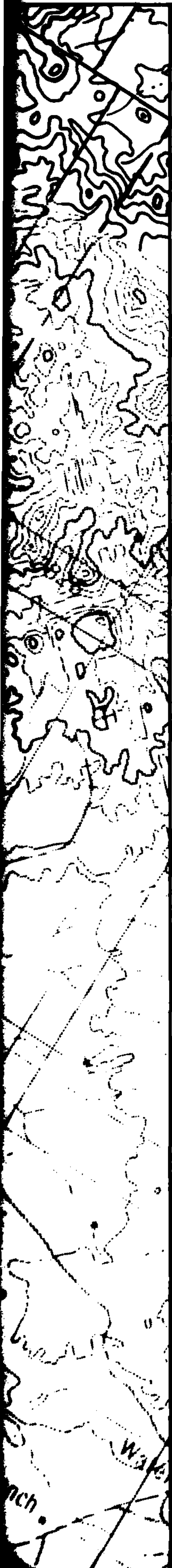
3

- 6



RESERVOIR
SANTA MARIA RIVER
MOHAVE CO
YAVAPAI COUN
3000
2000
I3
I2
A5os
A5ys
A5ig
A5is
A5og
A5og (M)
A4of
A4os/A4of
A5os/A4of
A1s/A5ys
A5ys/A1s
A5is A5os
Ranch

M 4 1



EXPLANATION

SURFICIAL BASIN-FILL UNITS

A1s / A1g	Younger Fluvial Deposits - Modern stream channel and flood-plain deposit sand and gravelly sand (SP) and A1g, sandy gravel (GP).
A3d	Eolian Deposits - Windblown sand (SP) in stabilized dunes.
A4of	Older playa and Lacustrine Deposits - Older playa and lake bed deposits silt (ML), clay (CL) and moderately cemented silty sand (SM) and sand (SP
A5ys / A5yg	Younger Alluvial Fan Deposits - Active, younger alluvial fan deposits of sand and gravelly sand (SM) and A5yg, sandy gravel (GP, GM).
A5is / A5ig	Intermediate Alluvial Fan Deposits - Inactive, intermediate age alluvial A5is, weakly cemented silty sand and gravelly sand (SM) and A5ig, weakly
A5os / A5og	Older Alluvial Fan Deposits - Older, highly eroded alluvial fan deposits silty sand and gravelly sand (SM) and A5og, weakly cemented sandy gravel

ROCK UNITS

Igneous (I)

I1	Granite, quartz monzonite, granodiorite, and quartz diorite
I2	Intermediate flows and tuffs, chiefly andesite.
I3	Basalt

Sedimentary (S)

S5	Arkosic conglomerate, sandstone, and siltstone.

Metamorphic (M)

M	Gneiss, local schist and granite.

A5os/A4of — Combination of geologic unit symbols indicates a mixture of either surfi basin-fill or rock units inseparable at map scale.

A5ys (I2) — Parenthetic unit underlies surface unit at shallow depth.

SYMBOLS

Contact between rock and basin-fill.

Contact between surficial basin-fill or rock units.

EXPLANATION

FICIAL BASIN-FILL UNITS

Modern stream channel and flood-plain deposits of: Als,) and Alg, sandy gravel (GP).

sand (SP) in stabilized dunes.

Deposits - Older playa and lake bed deposits of interbedded derately cemented silty sand (SM) and sand (SP).

its - Active, younger alluvial fan deposits of: A5ys, silty) and A5yg, sandy gravel (GP, GM).

Deposits - Inactive, intermediate age alluvial fan deposits of: ty sand and gravelly sand (SM) and A5ig, weakly cemented sandy gravel (GM).

ts - Older, highly eroded alluvial fan deposits of: A5os, weakly cemented nd (SM) and A5og, weakly cemented sandy gravel (GM).

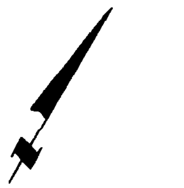
ROCK UNITS

, granodiorite, and quartz diorite

ffs, chiefly andesite.

dstone, and siltstone.

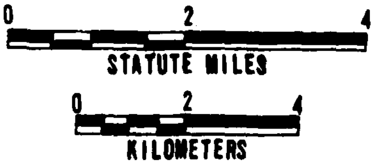
ranite.



nit symbols indicates a mixture of either surficial inseparable at map scale.

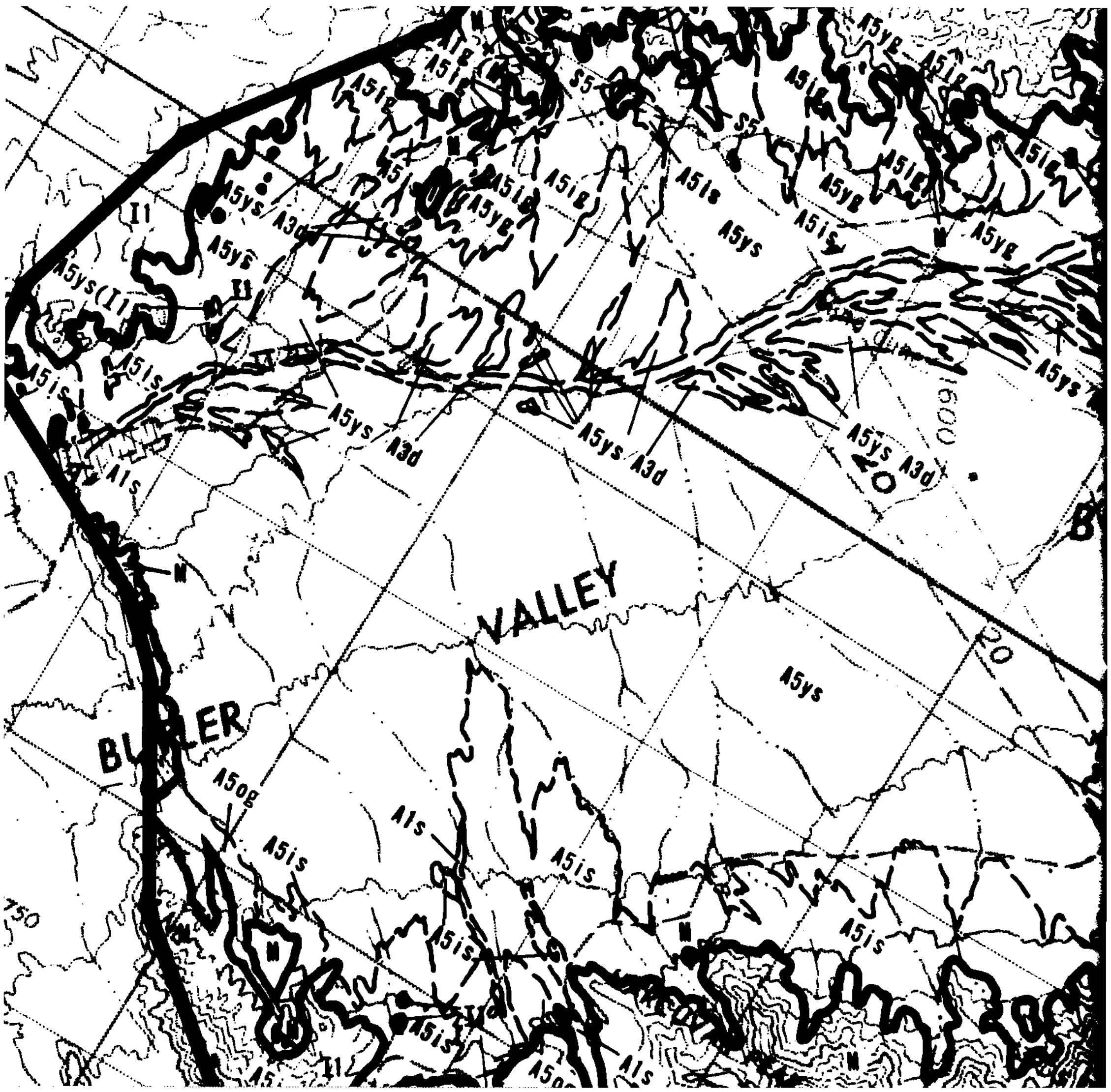
SCALE 1:125,000

s surface unit at shallow depth.



SYMBOLS

basin-fill.



VALLEY
BUTLER
A5ys
A5is
A5ig
A5yg
A5ys/A3d
A3d
A1s
A5og
I1
S5
1600
20
750


BUTLER VALLEY
HARCUVAR
Corral
8
3000
2000
1600
A5ys
A5ig
A5og
A5is
A5yg
A5os
A1s
A1g
A3d
A5ys A3d
A5og (M)
A5ig (M)
A5ys/A1s
S5
I1
M

MARIA RIVER
MOHAVE CO
YUMA
YAVAPAI COUNTY
MOUNTAINS
BULLARD PEAK
YUMA COUNTY
YAVAPAI COUNTY
Ranch
2000
3000
2476
28
A5is
A5ys
A5og
A5os/A4of
A4of
A1s
I2
I3

A3d Eolian Deposits - Windblown sand (SP) in stabilized dunes.

A4of Older playa and Lacustrine Deposits - Older playa and lake bed deposits of silt (ML), clay (CL) and moderately cemented silty sand (SM) and sand (SP).

A5ys / A5yg Younger Alluvial Fan Deposits - Active, younger alluvial fan deposits of: sand and gravelly sand (SM) and A5yg, sandy gravel (GP, GM).

A5is / A5ig Intermediate Alluvial Fan Deposits - Inactive, intermediate age alluvial f A5is, weakly cemented silty sand and gravelly sand (SM) and A5ig, weakly c

A5os / A5og Older Alluvial Fan Deposits - Older, highly eroded alluvial fan deposits of silty sand and gravelly sand (SM) and A5og, weakly cemented sandy gravel (G

ROCK UNITS

Igneous (I)

I1 Granite, quartz monzonite, granodiorite, and quartz diorite

I2 Intermediate flows and tuffs, chiefly andesite.

I3 Basalt

Sedimentary (S)

S5 Arkosic conglomerate, sandstone, and siltstone.

Metamorphic (M)

M Gneiss, local schist and granite.

A5os/A4of Combination of geologic unit symbols indicates a mixture of either surficial basin-fill or rock units inseparable at map scale.

A5ys (I2) Parenthetic unit underlies surface unit at shallow depth.

SYMBOLS

Contact between rock and basin-fill

Contact between surficial basin-fill or rock units.

NOTES:

1. Surficial basin-fill units pertain only to the upper several feet of soil. Due to va surficial deposits and scale of map presentation, unit descriptions refer to the pred soil types. Varying amounts of other soil types can be expected within each geologic
2. The distribution of geologic data stations is presented in Volume II, Drawing 1. A all station data and generalized description of all geologic units is included in Vol Section 1.0.
3. Geology in areas of exposed rock for Sherborne et. al. (1979) and Wilson et. al. (19

9

sand (SP) in stabilized dunes.

Deposits - Older playa and lake bed deposits of interbedded
derately cemented silty sand (SM) and sand (SP).

its - Active, younger alluvial fan deposits of: A5ys, silty
) and A5yg, sandy gravel (GP, GM).

Deposits - Inactive, intermediate age alluvial fan deposits of:
y sand and gravelly sand (SM) and A5ig, weakly cemented sandy gravel (GM).

s - Older, highly eroded alluvial fan deposits of: A5os, weakly cemented
nd (SM) and A5og, weakly cemented sandy gravel (GM).

ROCK UNITS

granodiorite, and quartz diorite

ffs, chiefly andesite.

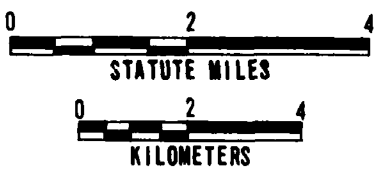
dstone, and siltstone.

anite.

it symbols indicates a mixture of either surficial
inseparable at map scale.

SCALE 1:125,000

s surface unit at shallow depth.



SYMBOLS

basin-fill.

basin-fill or rock units.

rtain only to the upper several feet of soil. Due to variability of
of map presentation, unit descriptions refer to the predominant
of other soil types can be expected within each geologic unit.

data stations is presented in Volume II, Drawing 1. A tabulation of
zed description of all geologic units is included in Volume II.

ook for Sherborne et. al. (1979) and Wilson et. al. (1969).

SURFICIAL GEOLOGIC UNITS VERIFICATION SITE, ~~BUTLER CDP~~, ARIZONA	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	DRAWING 4-2

FUGRO NATIONAL, INC.

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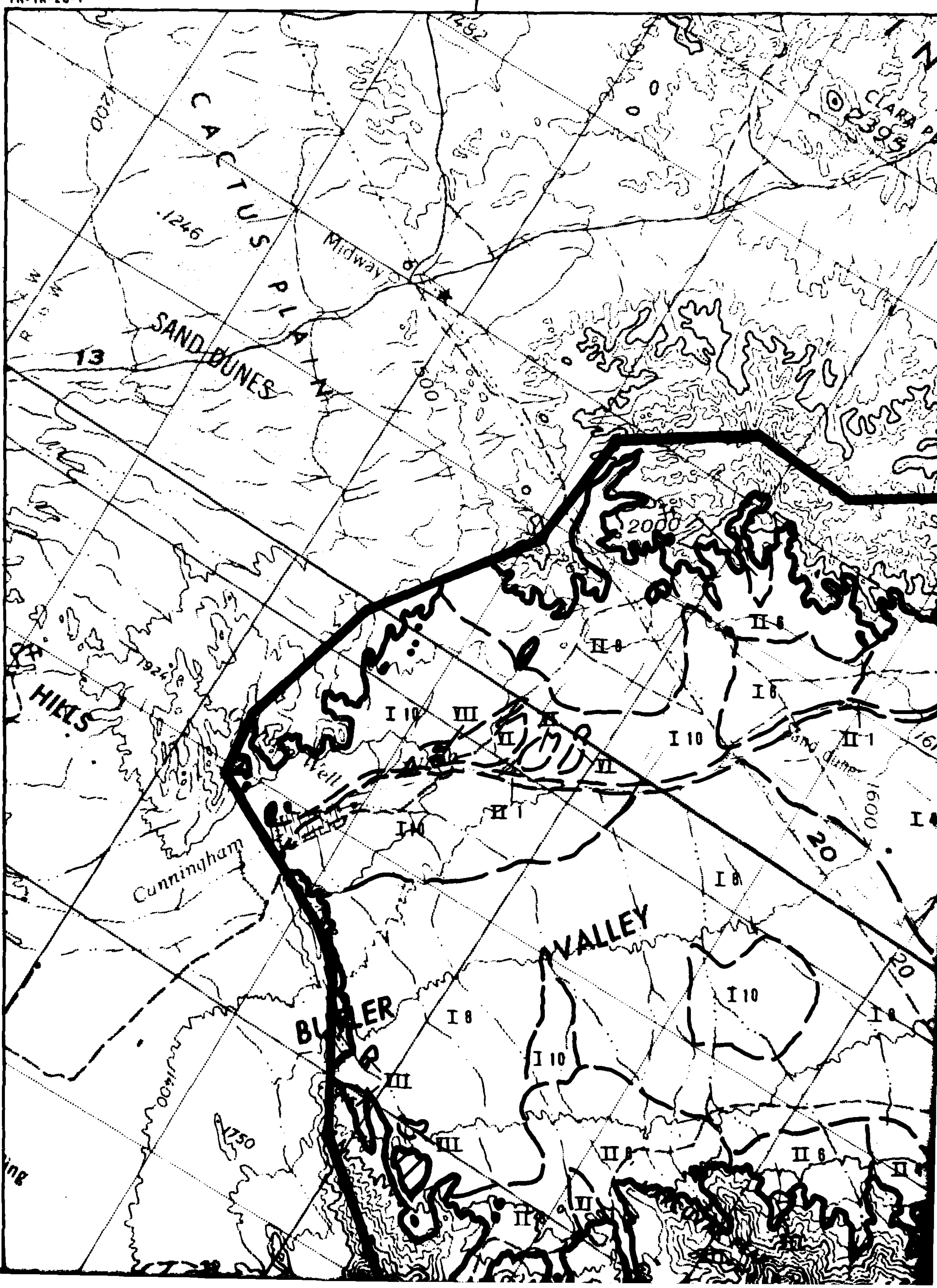
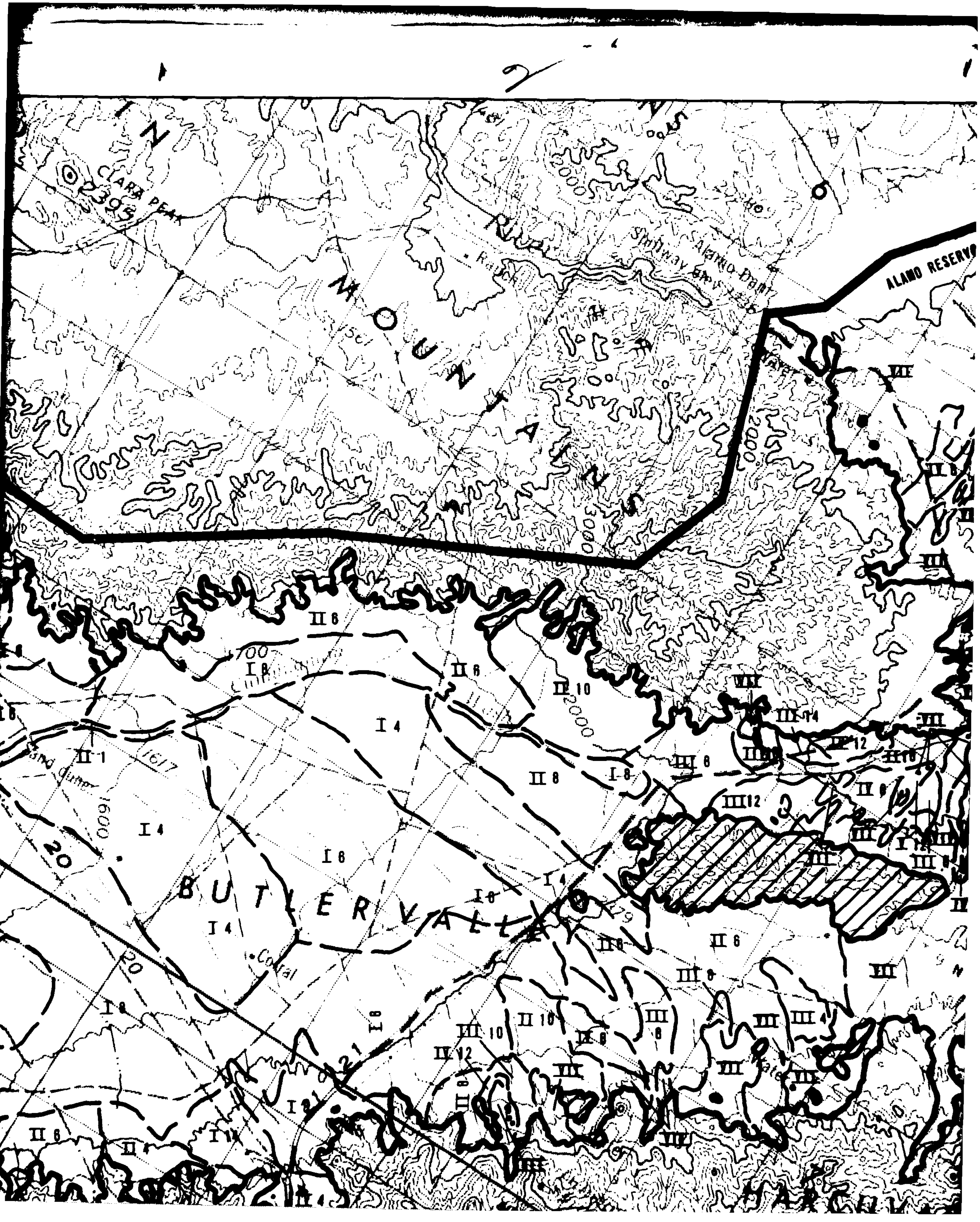

CACTUS PLAIN
SAND DUNES
Midway
1246
1400
1482
2399
2000
13
HILLS
1924
Well
Cunningham
VALLEY
R
Sand dunes
1600
1750
20
I 10
I 8
I 6
II 8
II 6
II 1
III
ing



MOUNTAINS
CLARA PEAK
2395
ALAMO RESERVOIR
Spillway Elev 1235
Alamo Dam
BUTLER VALLEY
Sand Dunes
Corral
II 6
I 8
II 6
II 10
I 4
II 1
II 8
I 8
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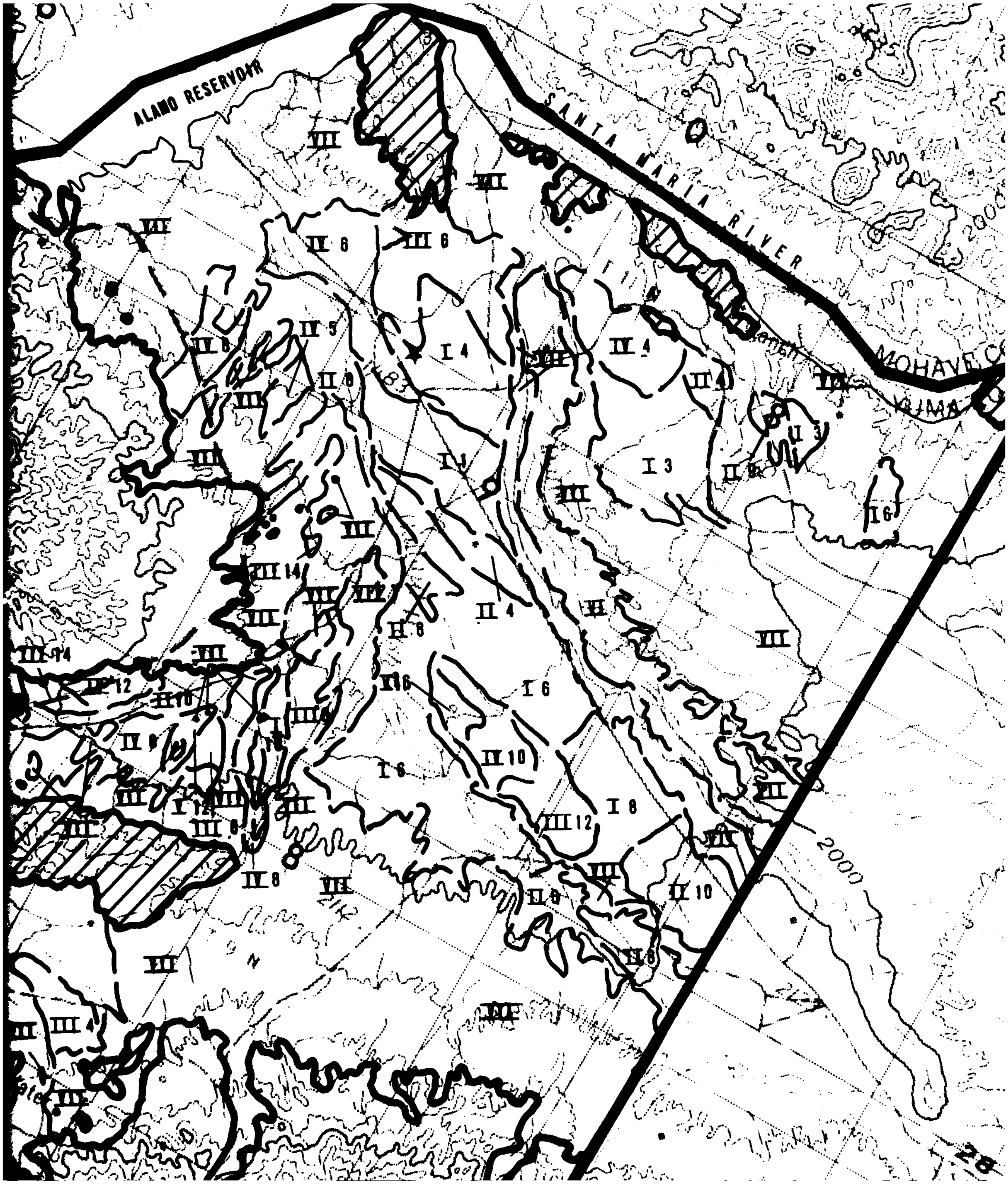
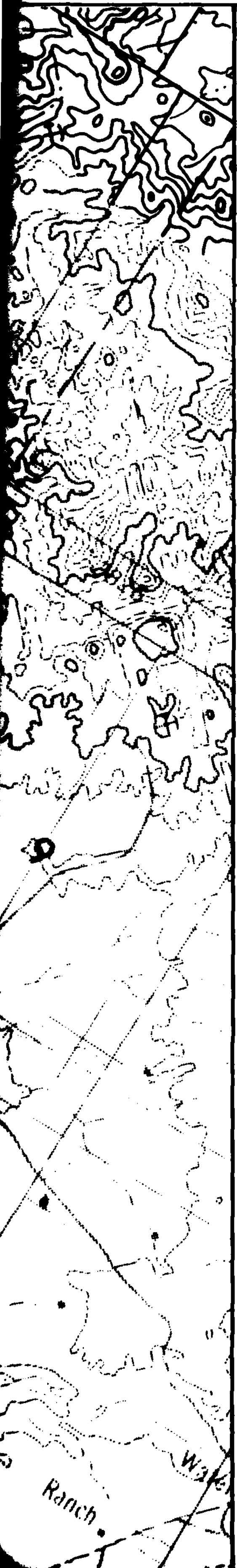
III 10
II 12
I 8
II 6


ALAMO RESERVOIR
SANTA MARIA RIVER
MOHAVE CO
YUMA
2000

4



EXPLANATION

Terrain Category — — — III 3 — — — Drainage spacing, i.e. the maximum number of drainages of the corresponding category occuring in a random traverse of one statute mile (1.6km)
(See table below)

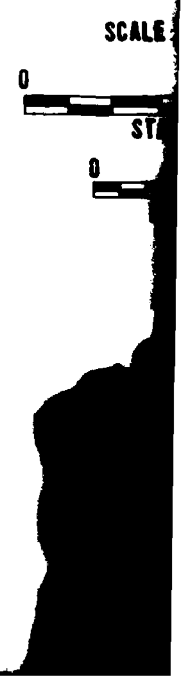
TERRAIN CATEGORY	DRAINAGE DEPTH DESCRIPTION
I	Less than 3 feet (1m)
II	3-6 feet (1-2m)
III	6-10 feet (2-3m)
IV	10-15 feet (3-5m)
V	Greater than 15 feet (5m)
VI	Complex, highly variable terrain not defined by drainage incision (e.g. dunal or hummocky terrains).
VII	Unsuitable terrain (see Appendix A2.0, Exclusion Criteria)

— — Contact between terrain categories.

Contact between rock and basin-fill.

Shading indicates areas of isolated exposed rock.

NOTE: Data used in constructing this map are from: (1) field observations, (2) 1:62,500 USGS topographic maps, and (3) 1:62,500 and 1:25,000 aerial photographs. Due to scale of presentation and variability of terrain conditions, this map is generalized.



4 -(1 5'

EXPLANATION

n Category — — — III 3 — — — Drainage spacing, i.e. the maximum number of drainages of the corresponding category occuring in a random traverse of one statute mile (1.6km)
able below)

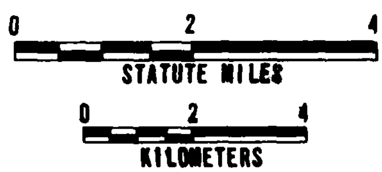
N CATEGORY	DRAINAGE DEPTH DESCRIPTION
I	Less than 3 feet (1m)
II	3-6 feet (1-2m)
III	6-10 feet (2-3m)
IV	10-15 feet (3-5m)
V	Greater than 15 feet (5m)
VI	Complex, highly variable terrain not defined by drainage incision (e.g. dunal or hummocky terrains).
VII	Unsuitable terrain (see Appendix A2.0, Exclusion Criteria)

Contact between terrain categories.

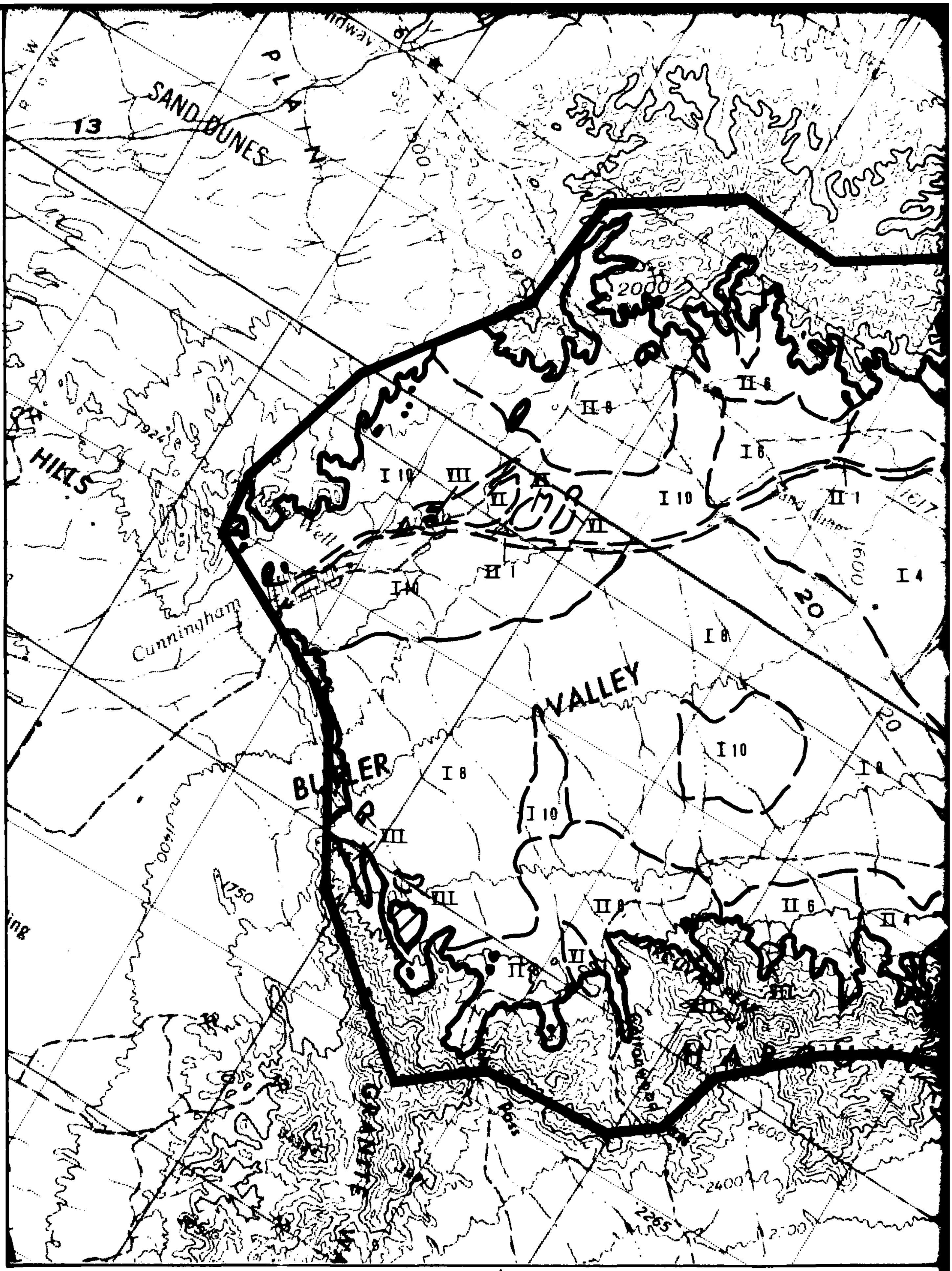
Contact between rock and basin-fill.

Shading indicates areas of isolated exposed rock.

SCALE 1:125,000

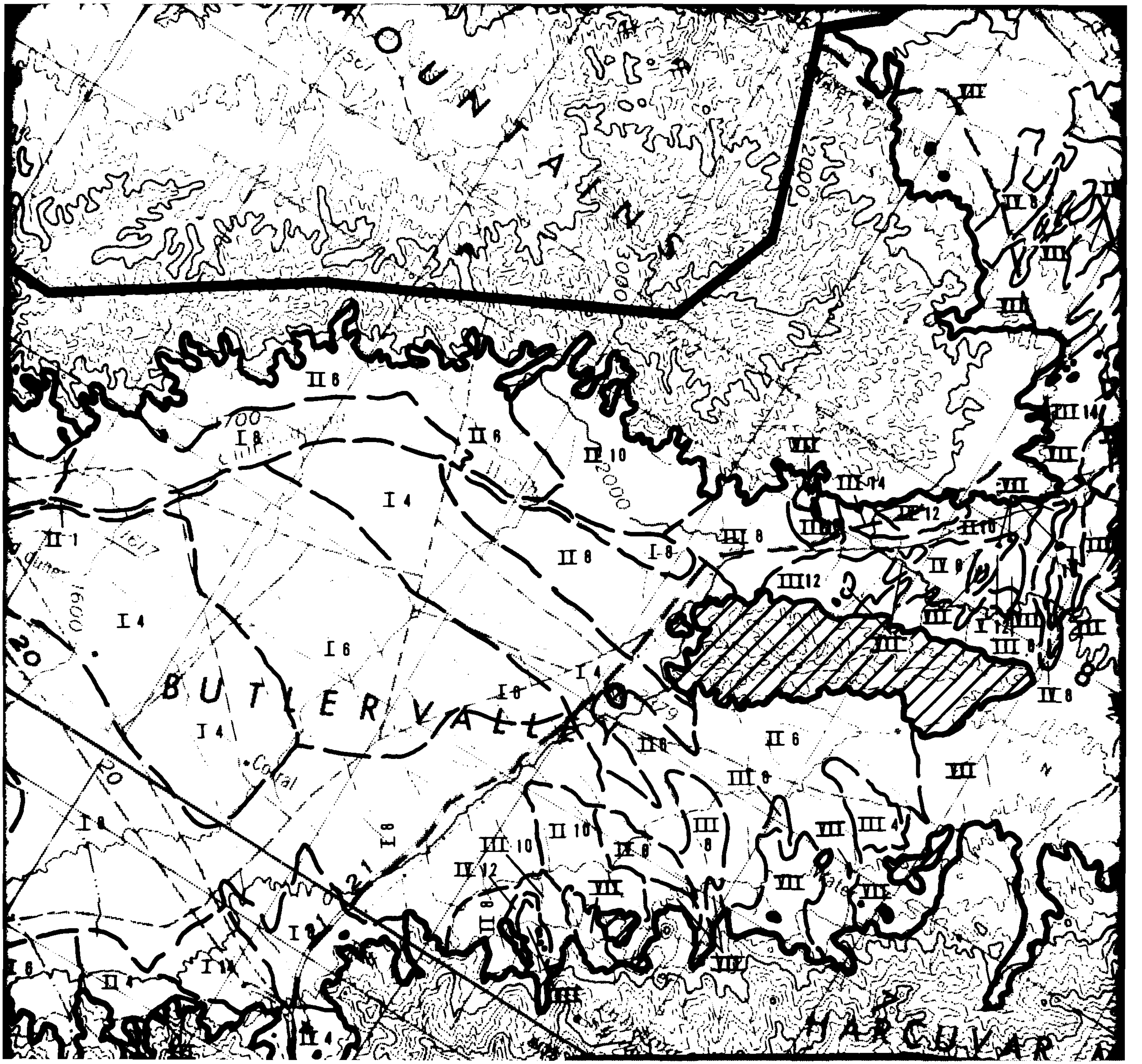


NOTE: Data used in constructing this map are from: (1) field observations, (2) 1:62,500 USGS topographic maps, and (3) 1:62,500 and 1:25,000 aerial photographs. Due to scale of presentation and variability of terrain conditions, this map is generalized.

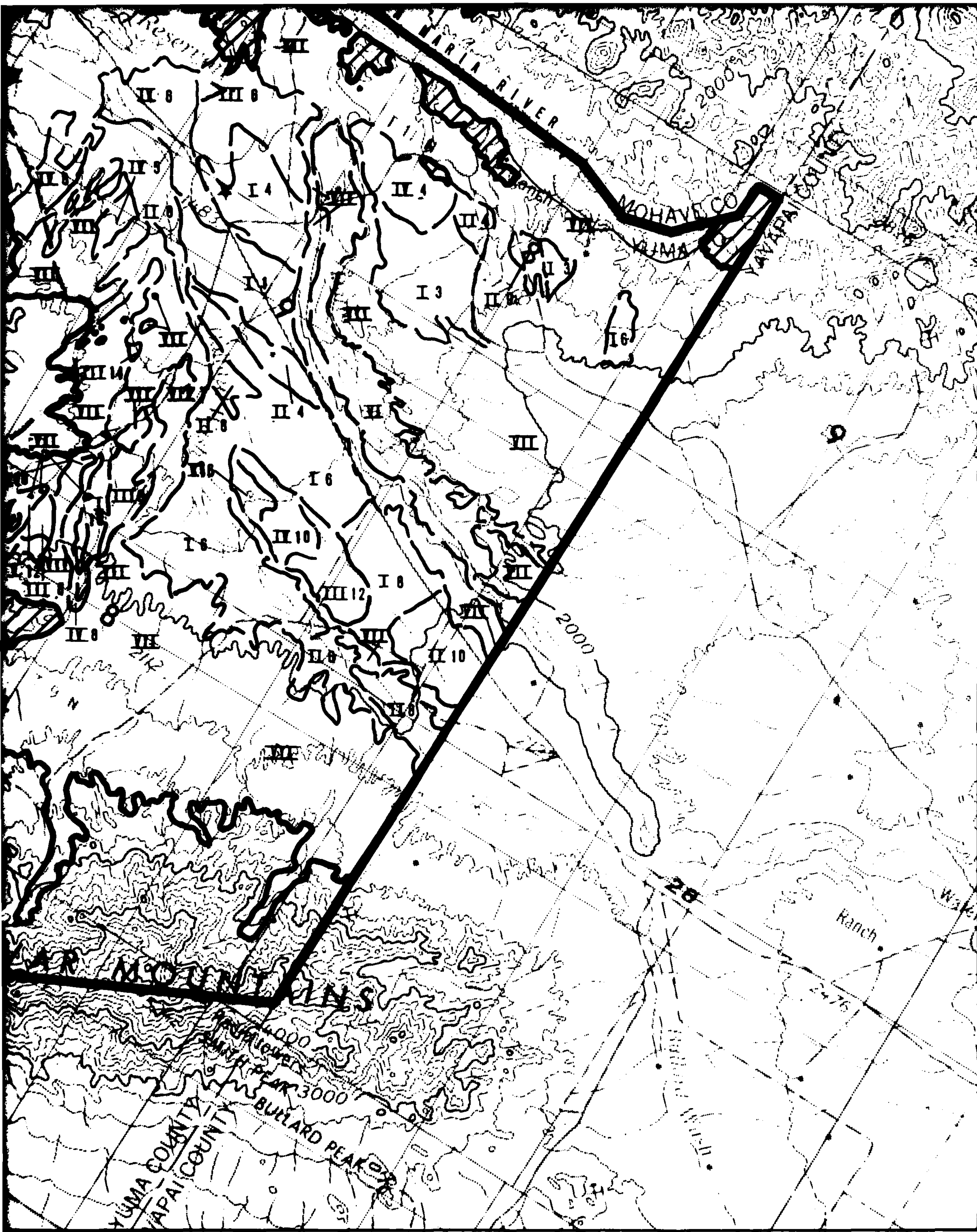


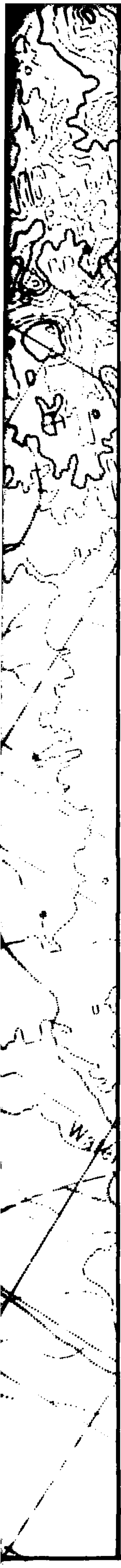
SAND DUNES
13
PLAIN
HILLS
Cunningham
VALLEY
BUTLER
2000
1924
20
1600
1400
1750
2600
2400
2265
2200
Pass
I 10
VII
II
VI
II 1
II 8
II 6
I 6
I 4
I 8
III

10 AUG 79



BUTLER VALLEY
HARCUVAR
2000
3000
1600
Corral


MARIA RIVER
MOHAVE CO
YUMA CO
YAVAPAI COUNTY
2000
MOUNTAINS
BULLARD PEAK
YUMA COUNTY
YAVAPAI COUNTY
3000
4000
Ranch
28



EXPLANATION

Terrain Category — — — III 3 — — — Drainage spacing, i.e. the maximum number of drainages of the corresponding category occuring in a random traverse of one statute mile (1.6km)
(See table below)

TERRAIN CATEGORY	DRAINAGE DEPTH DESCRIPTION
I	Less than 3 feet (1m)
II	3-6 feet (1-2m)
III	6-10 feet (2-3m)
IV	10-15 feet (3-5m)
V	Greater than 15 feet (5m)
VI	Complex, highly variable terrain not defined by drainage incision (e.g. dunal or hummocky terrains).
VII	Unsuitable terrain (see Appendix A2.0, Exclusion Criteria)

Contact between terrain categories.

Contact between rock and basin-fill.

Shading indicates areas of isolated exposed rock.

NOTE: Data used in constructing this map are from: (1) field observations, (2) 1:62,500 USGS topographic maps, and (3) 1:62,500 and 1:25,000 aerial photographs. Due to scale of presentation and variability of terrain conditions, this map is generalized.

SCALE 1:125,000

0 2
STATUTE MILES

0 2
KILOMETERS

TERRAIN
VERIFICATION SITE, DUTLE

MX SITING INVESTIGATIO
DEPARTMENT OF THE AIR FORCE

FUGRO NATI

EXPLANATION

ain Category — — — III 3 — — — Drainage spacing, i.e. the maximum number of drainages of the corresponding category occuring in a random traverse of one statute mile (1.6km)
table below)

AIN CATEGORY	DRAINAGE DEPTH DESCRIPTION
I	Less than 3 feet (1m)
II	3-6 feet (1-2m)
III	6-10 feet (2-3m)
IV	10-15 feet (3-5m)
V	Greater than 15 feet (5m)
VI	Complex, highly variable terrain not defined by drainage incision (e.g. dunal or hummocky terrains).
VII	Unsuitable terrain (see Appendix A2.0, Exclusion Criteria)

Contact between terrain categories.

Contact between rock and basin-fill.

Shading indicates areas of isolated exposed rock.

SCALE 1:125,000

0 2 4
STATUTE MILES

0 2 4
KILOMETERS

NOTE: Data used in constructing this map are from: (1) field observations, (2) 1:62,500 USGS topographic maps, and (3) 1:62,500 and 1:25,000 aerial photographs. Due to scale of presentation and variability of terrain conditions, this map is generalized.

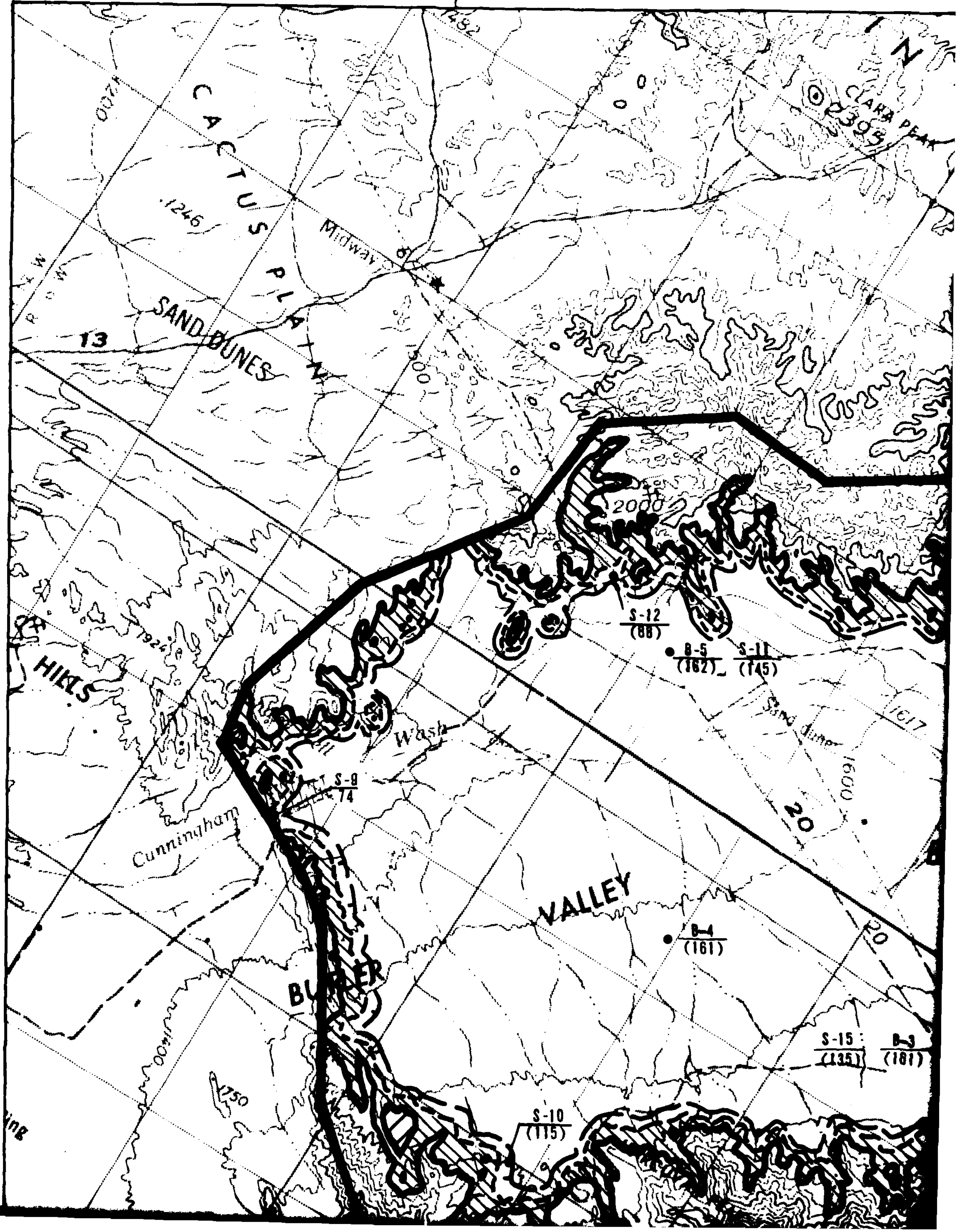
TERRAIN
VERIFICATION SITE, BUTLER CDP, ARIZONA

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE SAMSO	DRAWING 4-3

FUGRO NATIONAL, INC.

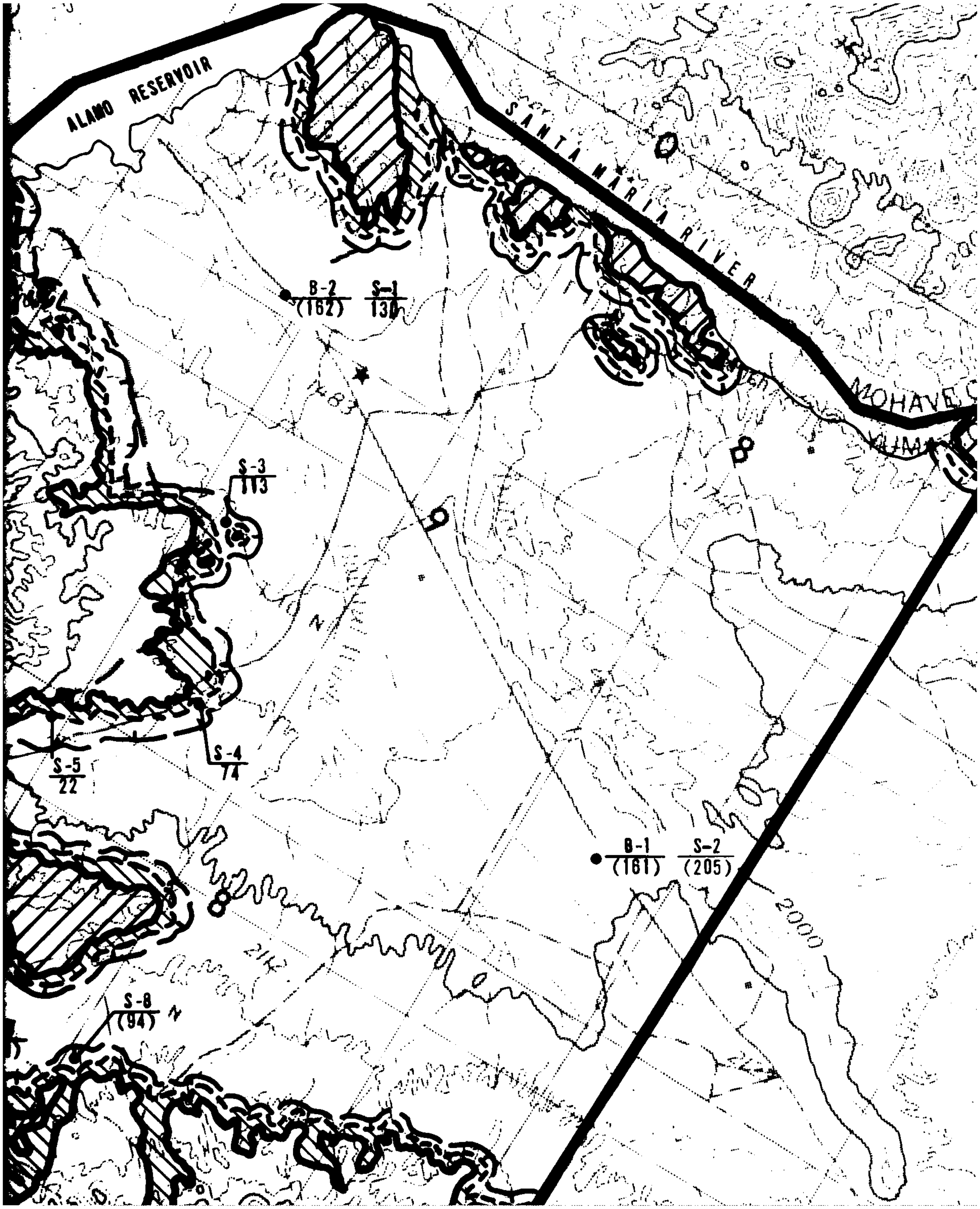
9

10



CACTUS PLAIN
SAND DUNES
Midway
13
CLARA PEAK
2395
1246
2000
S-12
(88)
B-5
(162)
S-11
(145)
HILLS
Wash
S-8
74
Cunningham
20
VALLEY
B-4
(161)
BUTLER
S-15
(135)
B-3
(181)
S-10
(115)
1750
1600

CLARA PEAK
2395
MOUNTAINS
ALAMO RESERVOIR
Alamo Dam
2000
3000
1700
S-16
35
S-5
22
1617
1600
20
S-6
(163)
BUTLER VALLEY
Corral
S-7
(94)
S-8
(94)
21
S-15
(135)
B-3
(161)
S-13
70
S-14
123



ALAMO RESERVOIR
SANTA MARIA RIVER
MOHAVE
B-2
(162)
S-1
130
S-3
113
S-4
74
S-5
22
S-8
(94)
B-1
(161)
S-2
(205)
2000

4

EXPLANATION

50 — Contour indicates rock at a depth of approximately 50 feet (15m) - shading indicates rock less than 50 feet (15m).

150 — Contour indicates rock at a depth of aproximately 150 feet (46m) - hachuring indicates rock less than 150 feet (46m)

Contact between rock and basin-fill.

Shading indicates areas of isolated exposed rock.

S4 / 75 — Data Source - Fugro boring (B), seismic refraction line (S), electrical resistivity sounding (R), or water well (W).

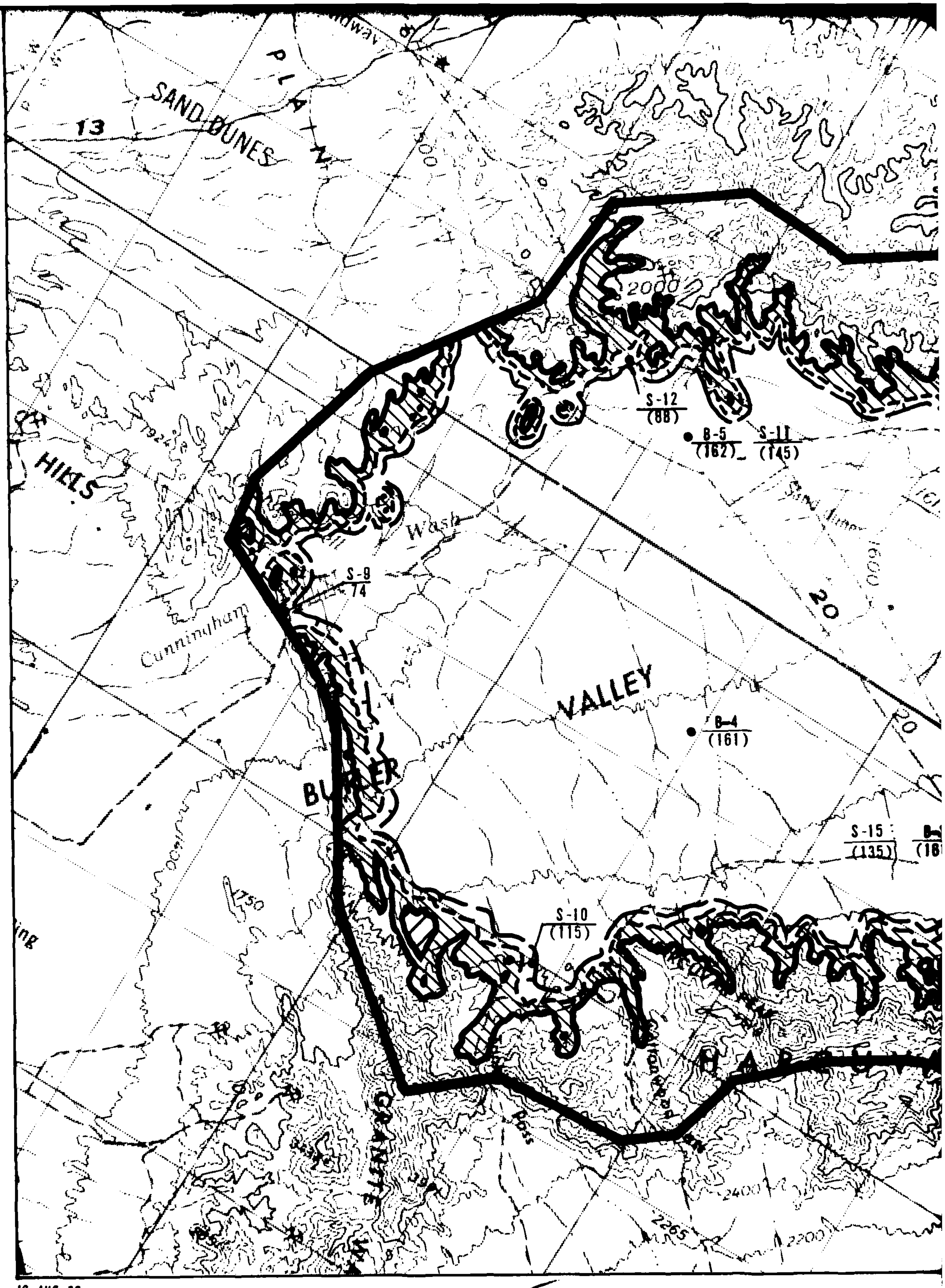
Depth to rock (feet) or, when in parentheses, depth above which rock does not occur (feet).

NOTE: The contours are based on geologic interpretations and the limited data points shown on the map. Some changes in contour locations can be expected as additional data are obtained.

SCALE 1:125,000

0 2 4
STATUTE MILES

0 2 4
KILOMETERS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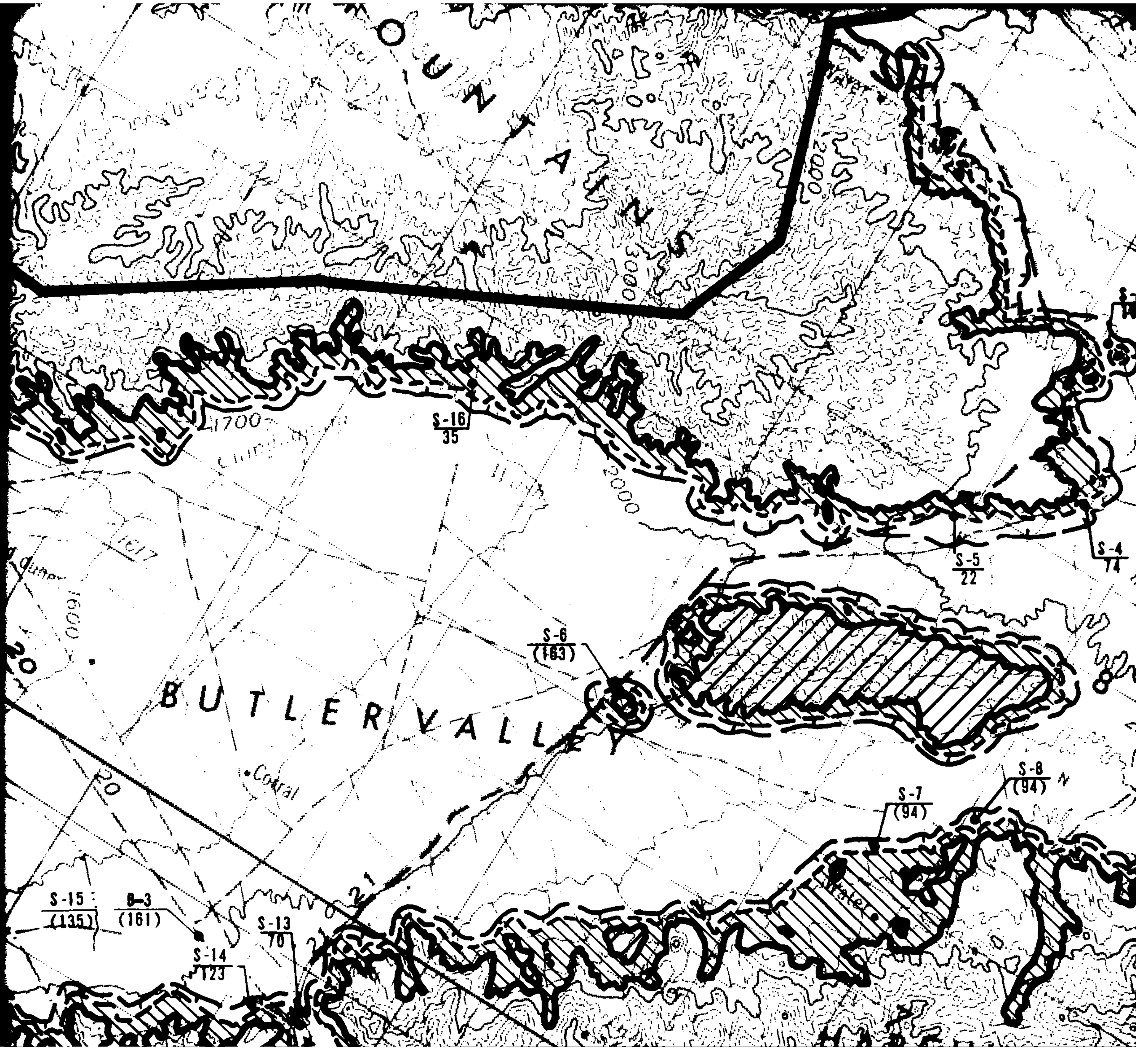
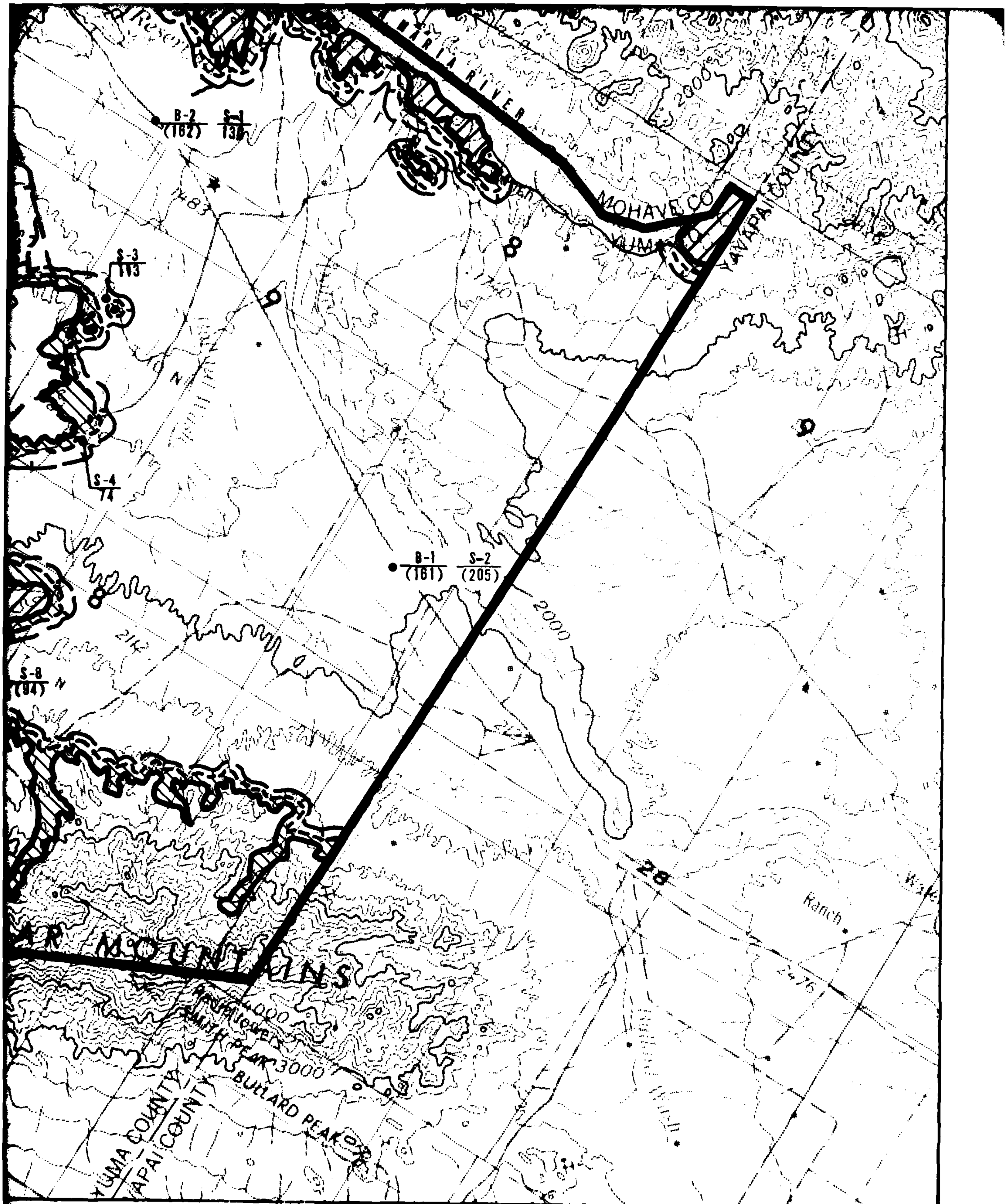
HILLS
2000
S-12
(88)
B-5
(162)
S-11
(145)
Wash
S-9
74
Cunningham
20
VALLEY
B-4
(161)
BUTLER
S-15
(135)
1750
S-10
(115)
2400
2265
2200

10 AUG 79

5



OUNTAINS
BUTLER VALLEY
S-16
35
S-6
(163)
S-5
22
S-4
74
S-7
(94)
S-8
(94)
S-15
(135)
B-3
(161)
S-13
70
S-14
123
1700
2000
3000
1600
Corral



B-2
(162)
S-1
130
S-3
113
S-4
74
S-8
(94)
B-1
(161)
S-2
(205)
MARIA RIVER
MOHAVE CO
YAVAPAI COUNTY
2000
28
Ranch
MOUNTAINS
SMITH PEAK 3000
BULLARD PEAK
YUMA COUNTY
YAVAPAI COUNTY

50 feet (15m) - shading indicates rock less than 50 feet (15m).

Contour indicates rock at a depth of approximately 150 feet (46m) - hachuring indicates rock less than 150 feet (46m)

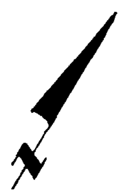
Contact between rock and basin-fill.

Shading indicates areas of isolated exposed rock.

Data Source - Fugro boring (B), seismic refraction line (S), electrical resistivity sounding (R), or water well (W).

Depth to rock (feet) or, when in parentheses, depth above which rock does not occur (feet).

NOTE: The contours are based on geologic interpretations and the limited data points shown on the map. Some changes in contour locations can be expected as additional data are obtained.



SCALE 1:125,000

0 2 4
STATUTE MILES

0 2 4
KILOMETERS

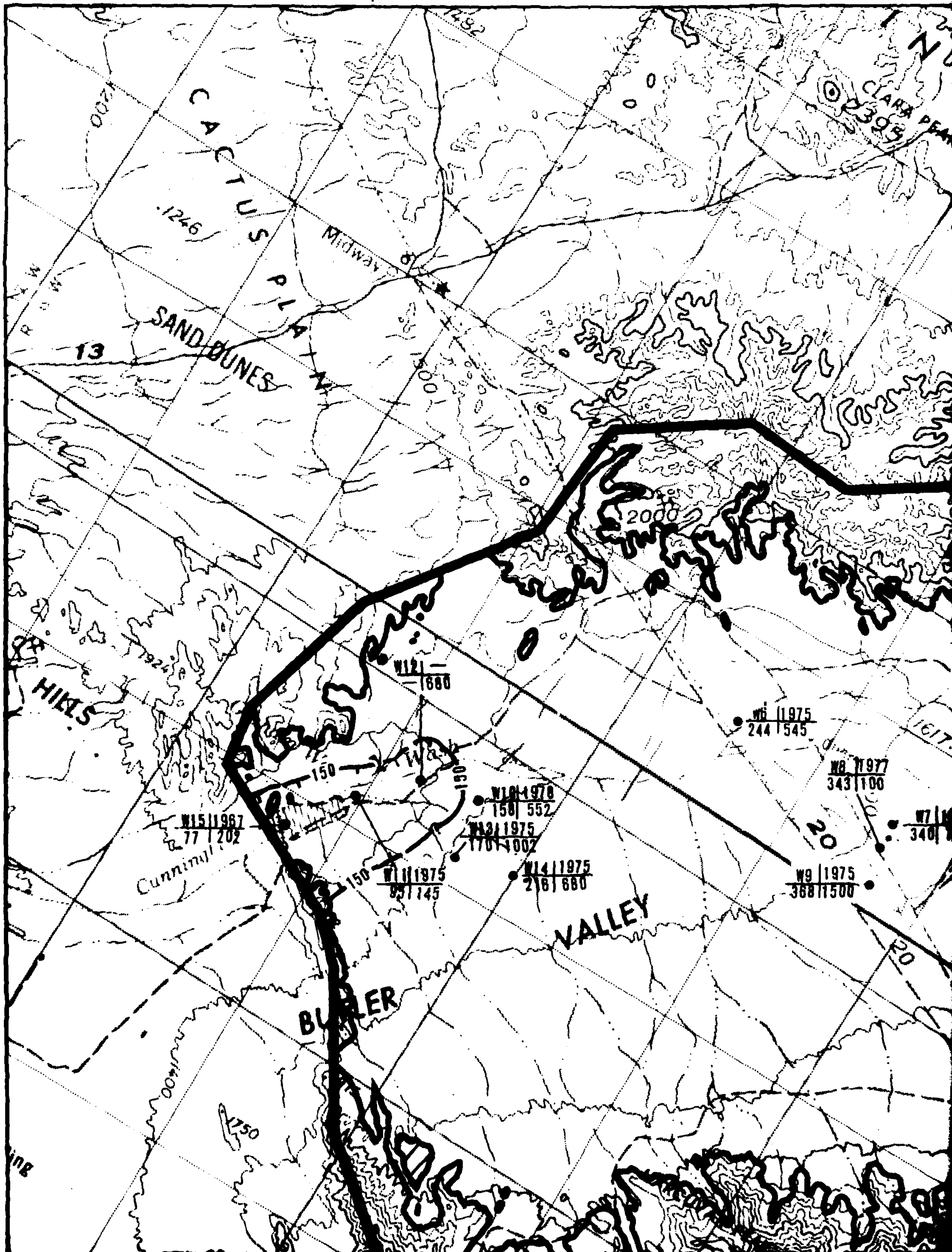
DEPTH TO ROCK
VERIFICATION SITE, BUTLER CDP, ARIZONA

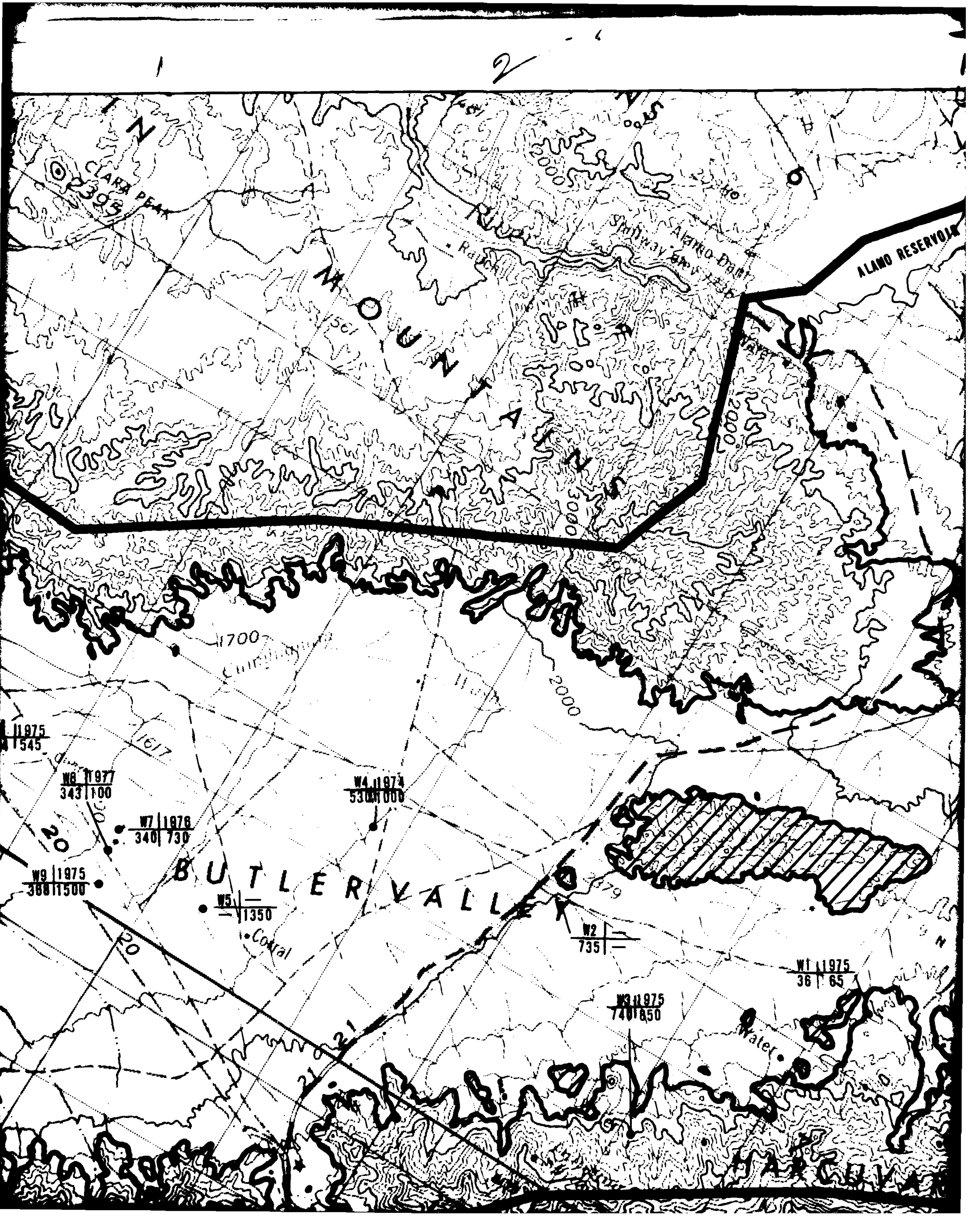
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

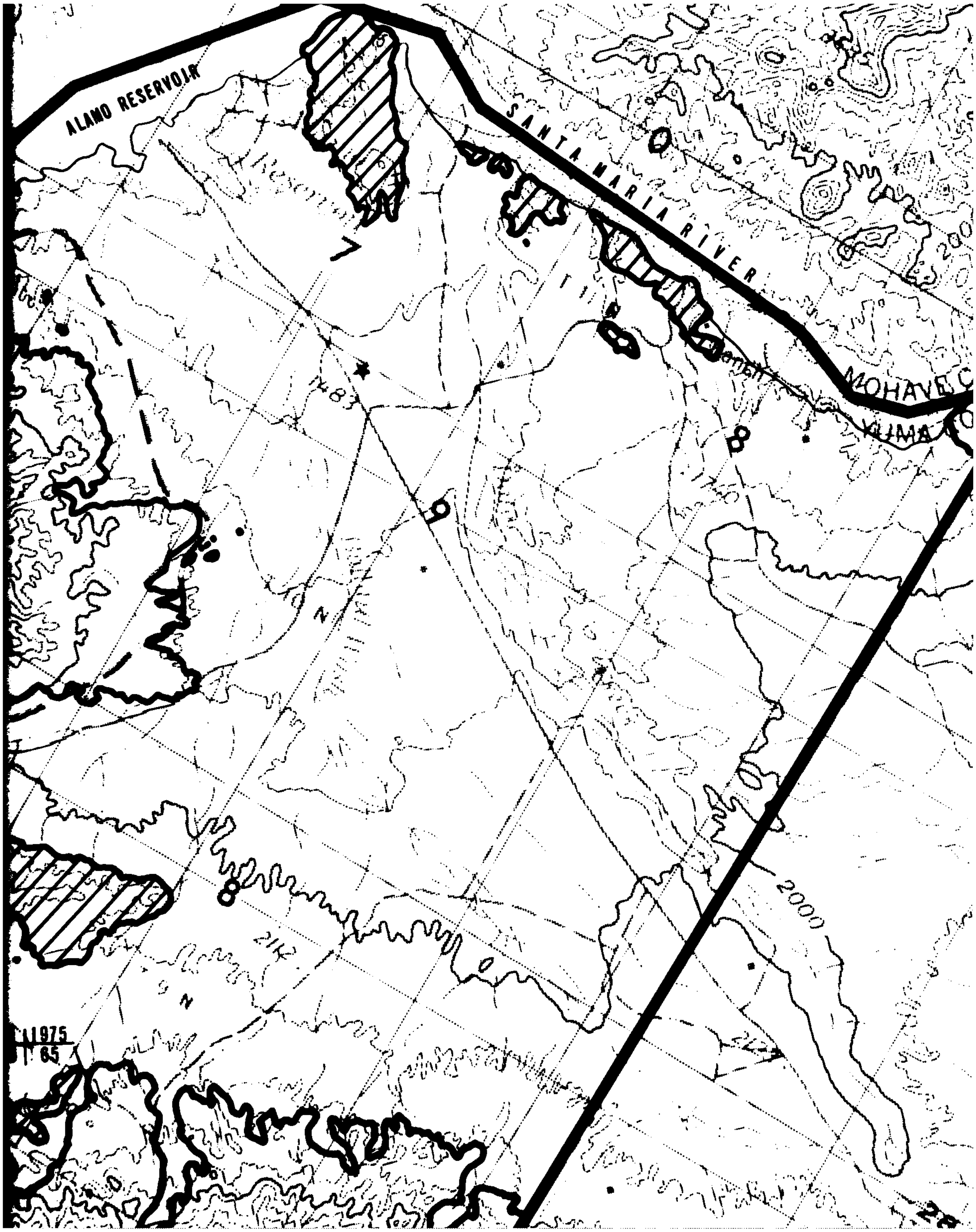
DRAWING 4-4

FUGRO NATIONAL, INC.

8

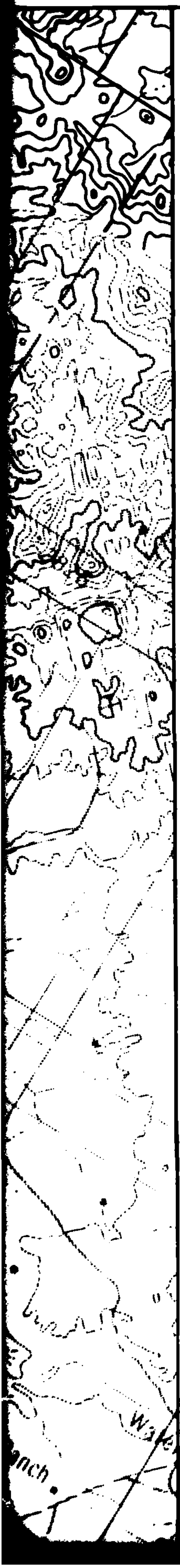

CACTUS PLAIN
SAND DUNES
Midway
13
1246
2395
2000
HILLS
W12
660
W6 1975
244 545
W8 1977
343 100
W10 1976
158 552
W15 1967
77 202
W13 1975
170 1002
W11 1975
145
W14 1975
680
W9 1975
368 1500
150
20
VALLEY
BUTLER
1750


1
2
CLARA PEAK
MOUNTAINS
ALAMO RESERVOIR
Alamo Dam
Spillway
1700
2000
3000
W6 1977
343 100
W7 1976
340 730
W9 1975
388 1500
W4 1974
W5
1350
Corral
BUTLER VALLEY
W2
735
W1 1975
36 65
W3 1975
740 850
Water
20
21



ALAMO RESERVOIR
SANTA MARIA RIVER
MOHAVE C
YUMA C
7
8
9
2000

1 4



EXPLANATION

Contour indicates ground water at a depth of approximately 50 feet (15m)-queried where data are extremely sparse. Shading indicates less than 50 feet (15m) to ground water.

Contour indicates ground water at a depth of approximately 150 feet (46m)-queried where data are extremely sparse. Hachuring indicates less than 150 feet (46m) to ground water.

Contact between rock and basin-fill.

Shading indicates areas of isolated exposed rock.

● W2 | 1973 / 15 | 700

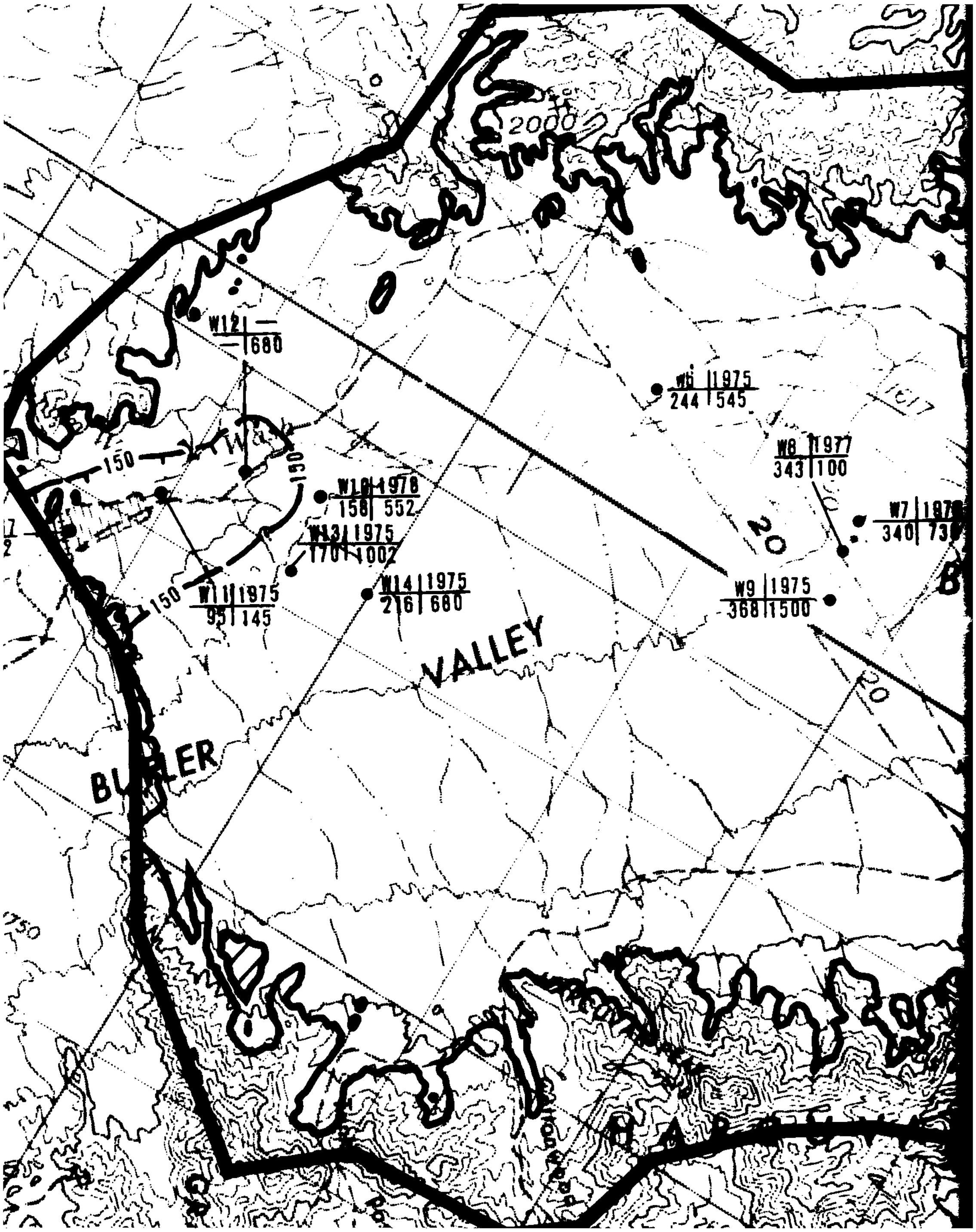
Data sourse-Fugro boring (B), seismic refraction line (S), electrical resistivity sounding (R), or water well (W); see Volume II Section 2.0.	Year of water level measurement
Depth to water (feet)	Depth of well (feet)

NOTE; The contours are based entirely on the data points shown on the map. Extensive interpretation has been used and it can be expected that contour locations will change as additional data are obtained.

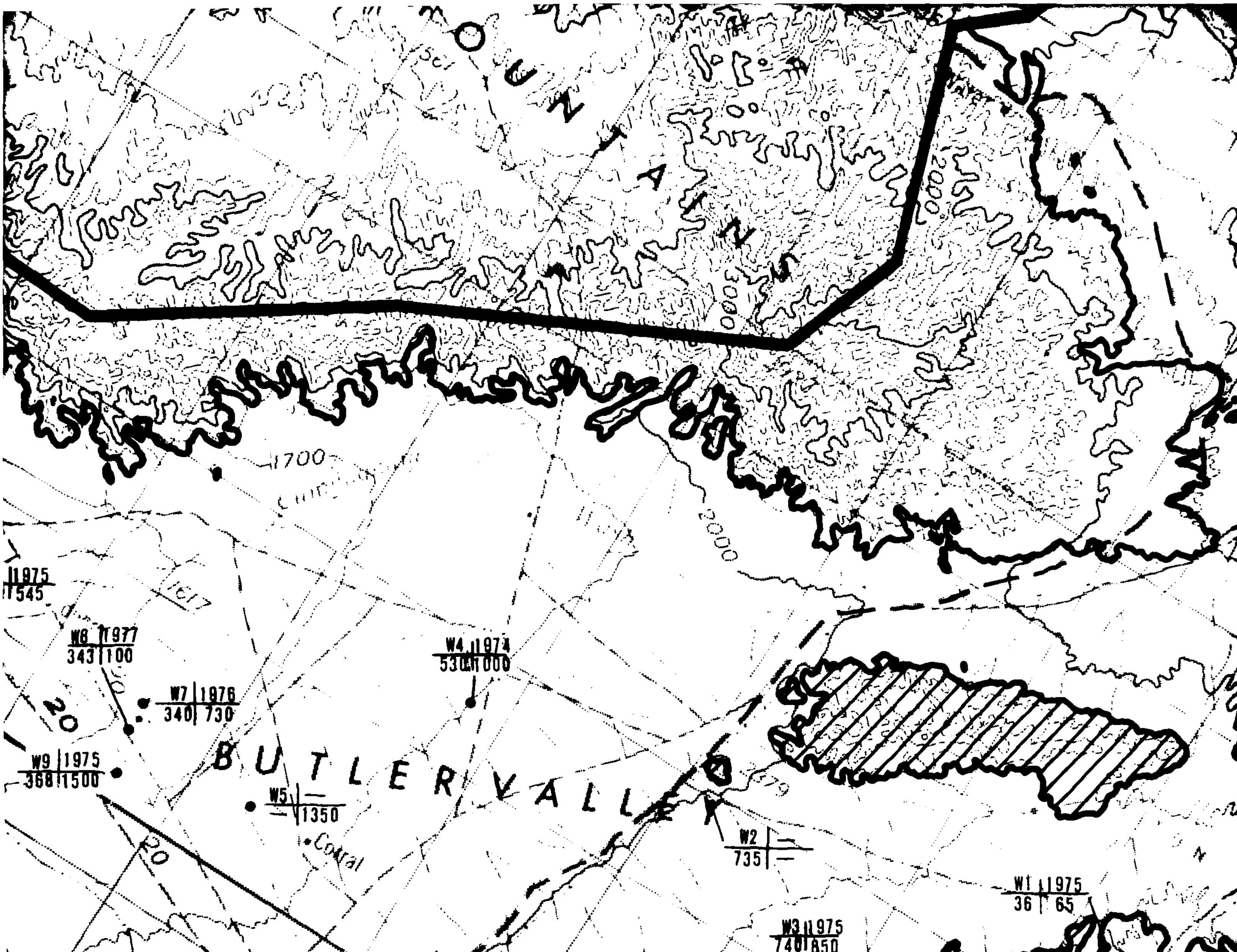
SCALE 1;125,000

0 2 4

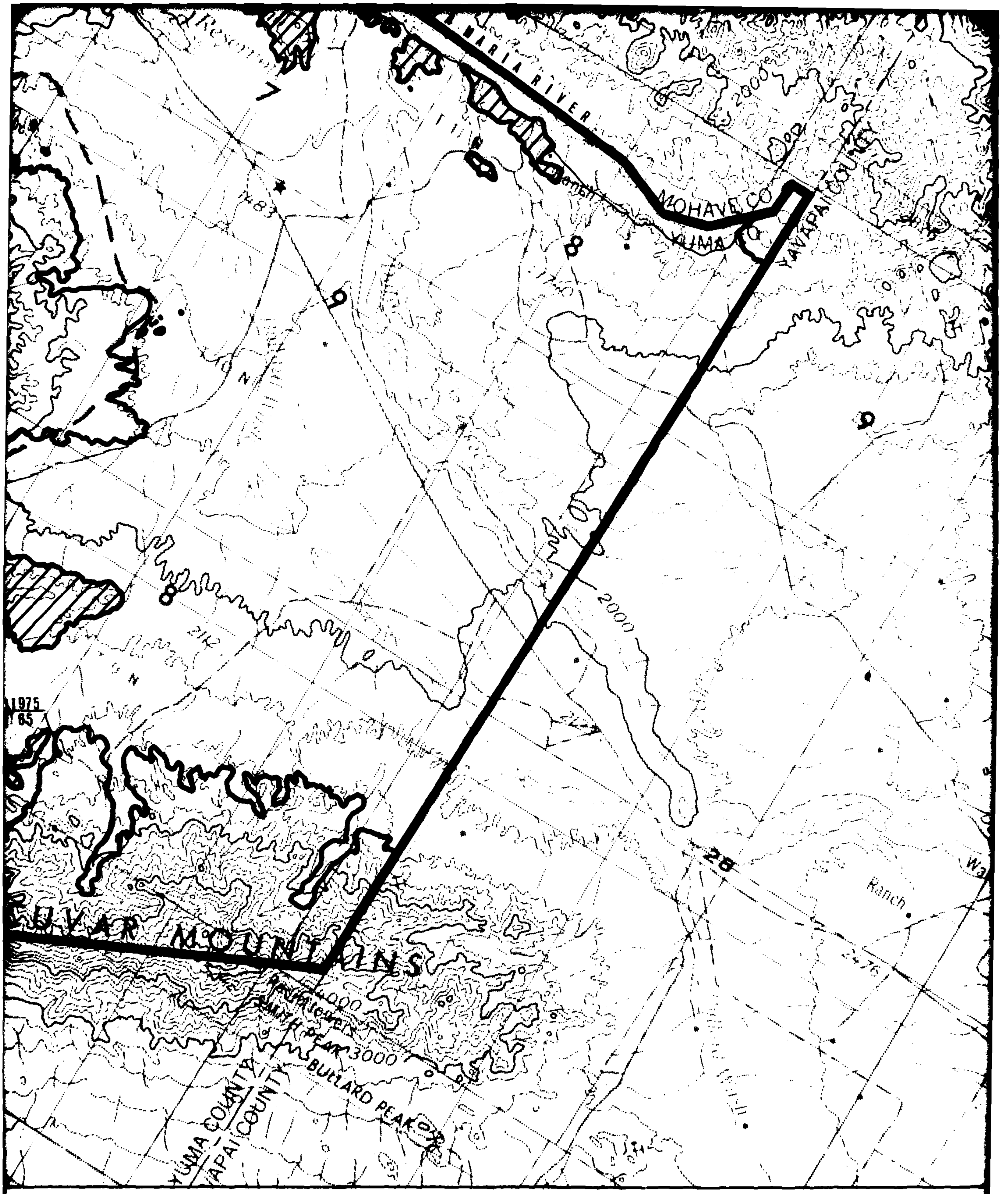
STATUTE MILES



2000
W12 | —
— | 680
W6 | 1975
244 | 545
W8 | 1977
343 | 100
W7 | 197
340 | 73
W10 | 1976
158 | 552
W13 | 1975
170 | 1002
W11 | 1975
95 | 145
W14 | 1975
216 | 680
W9 | 1975
368 | 1500
150
150
150
20
20
VALLEY
BUTLER



MOUNTAINS
3000
2000
1700
2000
1975
1545
W6 1977
343 100
W4 1974
530 1000
W7 1976
340 730
20
W9 1975
368 1500
BUTLER VALLEY
W5
1350
Corral
W2
735
W1 1975
36 65
W3 1975
740 850
Water
21
HARCUVAR
MOUNTAINS


SANTA MARIA RIVER
MOHAVE CO
YUMA CO
YAVAPAI COUNTY
2000
BUCKSKIN MOUNTAINS
SMITH PEAK 3000
BULLARD PEAK
YUMA COUNTY
YAVAPAI COUNTY
Ranch
28
2476

7

EXPLANATION

50 — Contour indicates ground water at a depth of approximately 50 feet (15m)-queried where data are extremely sparse. Shading indicates less than 50 feet (15m) to ground water.

150 — Contour indicates ground water at a depth of approximately 150 feet (46m)-queried where data are extremely sparse. Hachuring indicates less than 150 feet (46m) to ground water.

Contact between rock and basin-fill.

Shading indicates areas of isolated exposed rock.

● W2 | 1973 / 75 | 700

Data sourse-Fugro boring (B), seismic refraction line (S), electrical resistivity sounding (R), or water well (W); see Volume II Section 2.0.	Year of water level measurement
Depth to water (feet)	Depth of well (feet)

NOTE; The contours are based entirely on the data points shown on the map. Extensive interpretation has been used and it can be expected that contour locations will change as additional data are obtained.

SCALE 1:125,000

0 2 4
STATUTE MILES

0 2 4
KILOMETERS

DEPTH TO WATER
VERIFICATION SITE, BUTLER CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

DRAWING 4-5

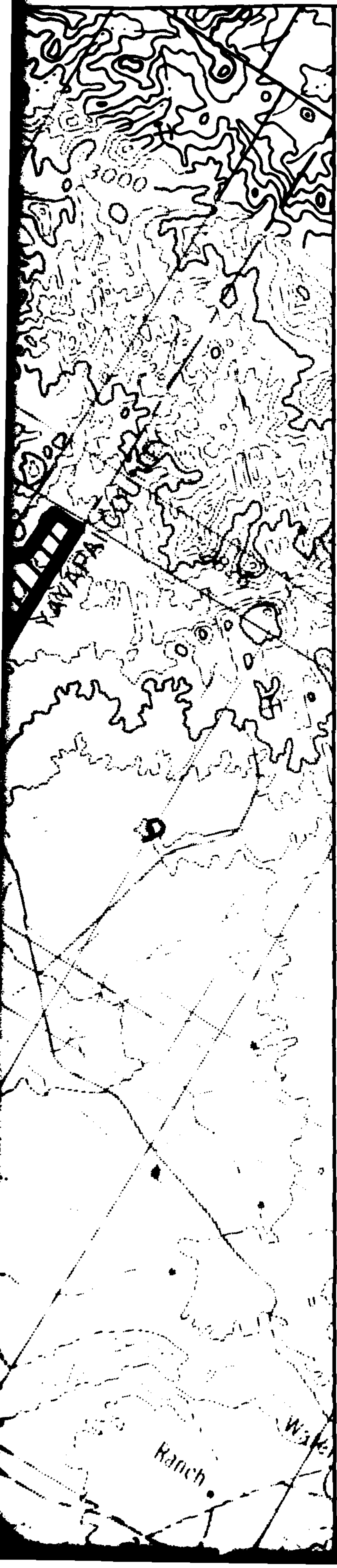
FUGRO NATIONAL, INC.


CACTUS PLAIN
SAND DUNES
Midway
CLARK
2395
1246
1292
13
HILLS
1924
Cunningham
Wash
Sand dunes
1600
20
VALLEY
BUTLER
1750
1
ing

CLARA PEAK
2395
MOUNTAINS
Alamo Dam
2000
3000
1700
1617
1600
20
BUTLER VALLEY
Corral
21


RIV
463

1 4



EXPLANATION

- (blank box) Area suitable for hybrid trench and vertical shelter basing modes. Depth to rock and water greater than 150 feet (46m).
- (diagonal hatch) Area suitable for hybrid trench and not suitable for vertical shelter. Depth to rock and water greater than 50 feet (15m) and less than 150 feet (46m).
- (solid black) Area unsuitable for both hybrid trench and vertical shelter basing modes as determined from application of depth to rock and water, topographic/terrain, and cultural exclusions.

Indicates areas of exposed rock.

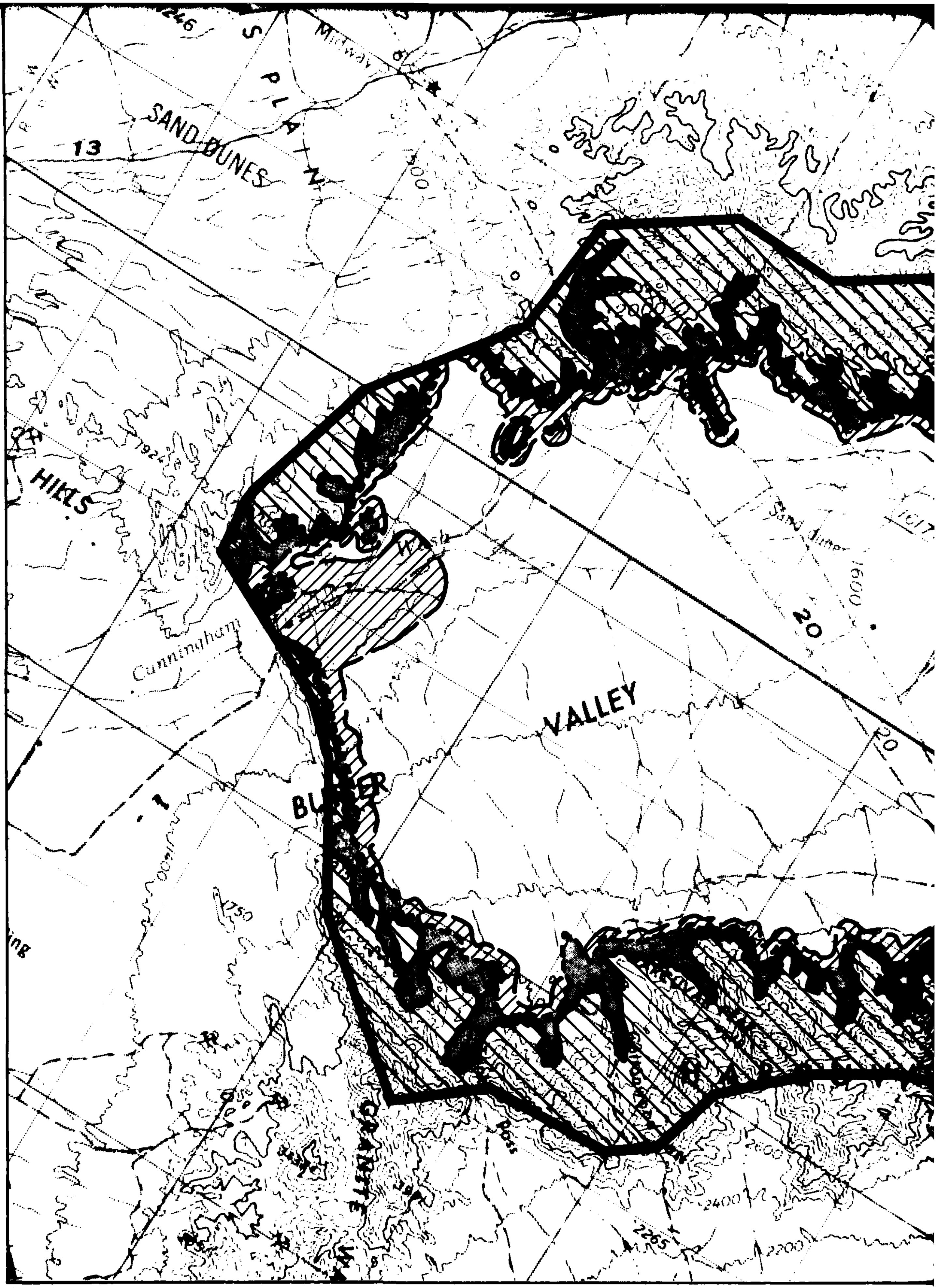
Contact between rock and basin-fill.

NOTE: See Appendix A2.0 Table A2-1 for details regarding suitable criteria.

SCALE 1:125,000

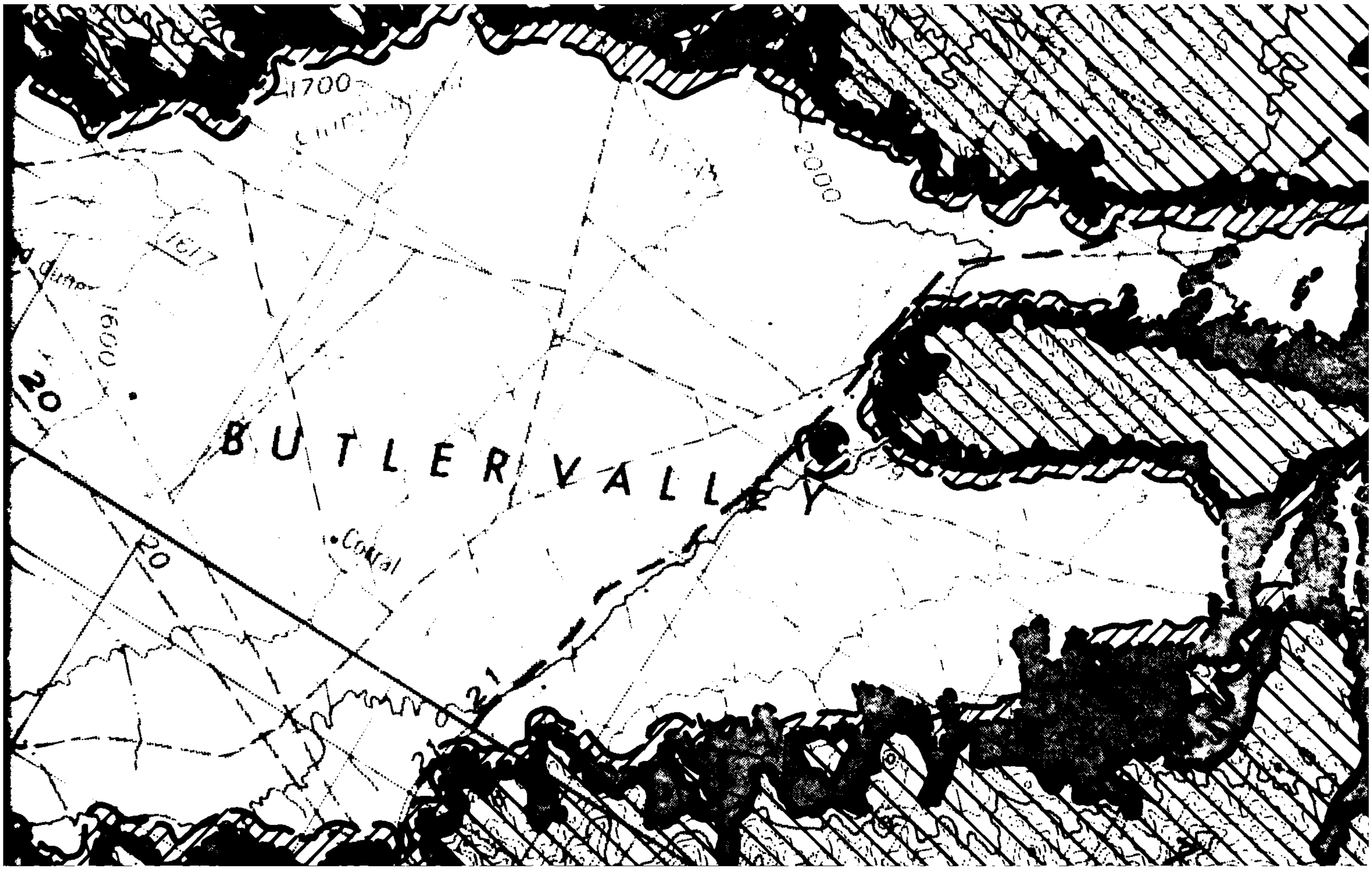
0 2 4
STATUTE MILES

0 2 4
KILOMETERS


SAND DUNES
13
Midway
HILLS
Cunningham
VALLEY
20
Sand dunes
1600
1750
2600
2400
2265
2200
GRANITE
Pass

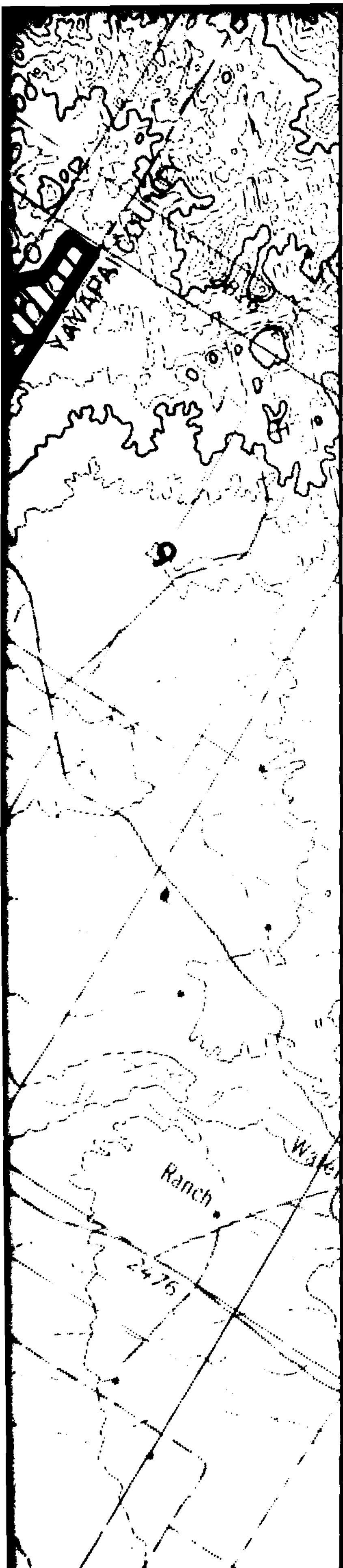
10 AUG 79

5



BUTLER VALLEY
1700
2000
1600
20
Corral

SANTA MARIA RIVER
MOHAVE CO
YAVAPAI COUNTY
2000
483
2000
28
Ranch
2476
MOUNTAINS
4000
3000
BULLARD PEAK
YUMA COUNTY
YAVAPAI COUNTY



EXPLANATION

- Area suitable for hybrid trench and vertical shelter basing modes. Depth to rock and water greater than 150 feet (46m).
- Area suitable for hybrid trench and not suitable for vertical shelter. Depth to rock and water greater than 50 feet (15m) and less than 150 feet (46m).
- Area unsuitable for both hybrid trench and vertical shelter basing modes as determined from application of depth to rock and water, topographic/terrain, and cultural exclusions.
- Indicates areas of exposed rock.
- Contact between rock and basin-fill.

NOTE: See Appendix A2.0 Table A2-1 for details regarding suitable criteria.

SCALE 1:125,000

0 2 4
STATUTE MILES

0 2 4
KILOMETERS

SUITABLE AREA
HYBRID TRENCH AND VERTICAL SHELTER
VERIFICATION SITE, BUTLER CDP, ARIZONA

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE SAMSO	DRAWING 4-6

FUGRO NATIONAL, INC.

8

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APPENDIX
TABLE OF CONTENTS

APPENDIX
TABLE OF CONTENTS (Cont.)

Page

LIST OF TABLES

LIST OF FIGURES

A1.0 GLOSSARY OF TERMS

ACTIVE FAULT - A fault which has had surface displacement within Holocene time (about the last 11,000 years).

ACTIVITY NUMBER - A designation composed of the valley abbreviation followed by the activity type and a unique number; may also be used to designate a particular location in a valley.

ALLUVIAL FAN DEPOSITS - Alluvium deposited by a stream or other body of running water as a sorted or semisorted sediment in the form of a cone or fan at the base of a mountain slope.

ALLUVIUM - A general term for unconsolidated clay, silt, sand, gravel, and boulders deposited during relatively recent geologic time by a stream or other body of running water as a sorted or semisorted sediment in the bed of a stream or on its flood plain or delta, or as a cone or fan at the base of a mountain slope.

ANOMALY - 1) A deviation from uniformity in physical properties; especially a deviation from uniformity in physical properties of exploration interest. 2) A portion of a geophysical survey which is different in appearance from the survey in general.

APPARENT RESISTIVITY (See Resistivity) - The ground resistivity calculated from measurements and a geometric factor (based on homogeneous and isotropic ground). This value includes the effect of all material influenced by the current induced into the ground and does not necessarily represent the true resistivity of any particular material or zone.

AQUIFER - A permeable saturated zone below the earth's surface capable of conducting and yielding water as to a well.

ARRIVAL - An event; the appearance of seismic energy on a seismic record; a lineup of coherent energy signifying the arrival of a new wave train.

ATTERBERG LIMITS - A general term applied to the various tests used to determine the various states of consistency of fine-grained soils. The four states of consistency are solid, semisolid, plastic, and liquid.

Liquid limit (LL) - The water content corresponding to the arbitrary limit between the liquid and plastic states of consistency of a soil (ASTM D423-66).

Plastic limit (PL) - The water content corresponding to an arbitrary limit between the plastic and the semisolid states of consistency of a soil (ASTM D424-59).

GLOSSARY OF TERMS (Cont.)

Plasticity index (PI) - Numerical difference between the liquid limit and the plastic limit indicating the range of moisture content through which a soil-water mixture is plastic.

BASIN-FILL MATERIAL/BASIN-FILL DEPOSITS - Heterogenous detrital material deposited in a sedimentary basin.

BASE LEVEL - The theoretical limit or lowest level toward which erosion constantly progresses; the level at which neither erosion or deposition takes place.

BEDROCK - A general term for the rock, usually solid, that underlies soil or other unconsolidated, surficial material.

BORING - A method of subsurface exploration whereby an open hole is formed in the ground through which soil-sampling or rock-drilling may be conducted.

BOUGUER ANOMALY - The residual value obtained after latitude, elevation, and terrain corrections have been applied to gravity data.

BOULDER - A rock fragment, usually rounded by weathering and abrasion with an average diameter of 12 inches (305 mm) or more.

BULK SAMPLE - A disturbed soil sample (bag sample) obtained from cuttings brought to the ground surface by a drill rig auger or obtained from the walls of a trench excavation.

c - Cohesion (Shear strength of a soil not related to interparticle friction).

CALCAREOUS - Containing calcium carbonate; presence of calcium carbonate is commonly identified on the basis of reaction with dilute hydrochloric acid.

CALICHE - Gravel, sand, or other material cemented principally by calcium carbonate.

CALIFORNIA BEARING RATIO (CBR) - Is the ratio (in percent) of the resistance to penetration developed by a subgrade soil to that developed by a specimen of standard crushed rock base material (ASTM D1883-73). During the CBR test, the load is applied on the circular penetration piston (3 inches^2 base area; 19 cm^2) which is penetrated into the the soil sample at a constant penetration rate of 0.05 inch/ minute (1.2 mm/min). The bearing ratio reported for the soil is normally the one at 0.1 inch (2.5 mm) penetration.

GLOSSARY OF TERMS (Cont.)

CANDIDATE DEPLOYMENT PARCEL (CDP) - An area of 200 (520) to 660 square statute miles (1710 square kilometers) potentially suitable for MX siting. Each parcel should have a specific geographic description. (In the Basin and Range Physiographic province a parcel may correspond to a geographic valley and in Texas to some agri-economic unit.)

CLAY - Fine-grained soil (passes No. 200 sieve; 0.074 mm) that can be made to exhibit plasticity within a range of water contents and that exhibits considerable strength when air dry.

CLAY SIZE - That portion of the soil finer than 0.002 mm.

CLOSED BASIN - A catchment area draining to some depression or lake within its area, from which water escapes only by evaporation.

COARSE-GRAINED (or granular) - A term which applies to a soil of which more than one-half of the soil particles, by weight, are larger than 0.074 mm in diameter (No. 200 U.S. sieve size).

COARSER-GRAINED - A term applied to alluvial fan deposits which are predominantly composed of material (cobble) larger than 3 inches (76 mm) in diameter.

COBBLE - A rock fragment, usually rounded or subrounded with an average diameter between 3 and 12 inches (76 and 305 mm).

COMPACTION TEST - A type of test to determine the relationship between the moisture content and density of a soil sample which is prepared in compacted layers at various water contents (ASTM D1557-70).

COMPRESSIBILITY-Property of a soil pertaining to its susceptibility to decrease in volume when subjected to load.

COMPRESSIONAL WAVE -An elastic body wave in which particle motion is in the direction of propagation; the type of seismic wave assumed in conventional seismic exploration. Also called P-wave, dilatational wave, and longitudinal wave.

CONDUCTIVITY - The ability of a material to conduct electrical current. In isotropic material, conductivity is the reciprocal of resistivity. Units are mhos per meter.

GLOSSARY OF TERMS (Cont.)

CONE PENETROMETER TEST - A method of evaluating the in-situ engineering properties of soil by measuring the penetration resistance developed during the steady slow penetration of a cone (60° apex angle, 10-cm^2 projected area) into soil.

Cone resistance or end bearing resistance, q_c - The resistance to penetration developed by the cone, equal to the vertical force applied to the cone divided by its horizontally projected area.

Friction resistance, f_s - The resistance to penetraton developed by the friction sleeve, equal to the vertical force applied to the sleeve divided by its surface area. This resistance consists of the sum of friction and adhesion.

Friction ratio, f_R - The ratio of friction resistance to cone resistance, f_s/q_c, expressed in percent.

CONSISTENCY - The relative ease with which a soil can be deformed.

CONSOLIDATION TEST - A type of test to determine the compressibility of a soil sample. The sample is enclosed in the consolidometer which is then placed in the loading device. The load is applied in increments at certain time intervals and the change in thickness is recorded.

CORE SAMPLE - A cylindrical sample obtained with a rotating core barrel with a cutting bit at its lower end. Core samples are obtained from indurated deposits and in rock.

DEGREE OF SATURATION - Ratio of volume of water in soil to total volume of voids.

DETECTOR - See GEOPHONE.

DIRECT SHEAR TEST - A type of test to measure the shear strength of a soil sample where the sample is forced to fail on a predetermined plane.

DISSECTION/DISSECTED (alluvial fans) - The cutting of stream channels into the surface of an alluvial fan by the movement (or flow) of water.

DRY UNIT WEIGHT/DRY DENSITY - Weight per unit volume of the solid particles in a soil mass.

ELECTRICAL CONDUCTIVITY - Ability of a material to conduct electrical current.

GLOSSARY OF TERMS (Cont.)

ELECTRICAL RESISTIVITY - Property of a material which resists flow of electrical current.

EOLIAN - A term applied to materials which are deposited by wind.

EPHEMERAL (stream) - A stream in which water flow is discontinuous and of short duration.

EXTERNAL DRAINAGE - Stream drainage system whose downgradient flow is unrestricted by any topographic impediments.

EXTRUSIVE (rock) - Igneous rock that has been ejected onto the earth's surface (e.g., lava, basalt, rhyolite, andesite; detrital material, volcanic tuff, pumice).

FAULT - A plane or zone of rock fracture along which there has been displacement.

FAULT BLOCK MOUNTAINS - Mountains that are formed by normal faulting in which the surface crust is divided into structural, partially to entirely fault-bounded blocks of different elevations.

FINE-GRAINED - A term which applies to a soil of which more than one-half of the soil particles, by weight, are smaller than 0.074 mm in diameter (passing the No. 200 U.S. size sieve).

FINER-GRAINED - A term applied to alluvial fan deposits, which are composed predominantly of material less than 3 inches (76 mm).

FLUVIAL DEPOSITS - Material produced by river action; generally loose, moderately well-graded sands and gravel.

FORMATION - A mappable assemblage of rocks characterized by some degree of homogeneity or distinctiveness.

FREE AIR ANOMALY - Gravity data which have been corrected for latitude and elevation (free air correction) but not for the density of rock between the datum and the plane of measurement (Bouguer correction).

FUGRO DRIVE SAMPLE - A 2.50-inch-(6.4-cm) diameter soil sample obtained from a drill hole with a Fugro drive sampler. The Fugro drive sampler is a ring-lined barrel sampler containing 12 one-inch-(2.54-cm) long brass sample rings. The sampler is advanced into the soil using a drop hammer.

GLOSSARY OF TERMS (Cont.)

GEOMORPHOLOGY - The study, classification, description, nature, origin, and development of present landforms and their relationships to underlying structures, and of the history of geologic changes as recorded by these surface features.

GEOPHONE - The instrument used to transform seismic energy into electrical voltage; a seismometer, jug, or pickup.

GRABEN - An elongated crustal block that has been downthrown along faults relative to the rocks on either side.

GRAIN-SIZE ANALYSIS (GRADATION) - A type of test to determine the distribution of soil particle sizes in a given soil sample. The distribution of particle sizes larger than 0.074 mm (retained on the No. 200 sieve) is determined by sieving, while the distribution of particle sizes smaller than 0.074 mm is determined by a sedimentation process, using a hydrometer.

GRANULAR - See Coarse-Grained.

GRAVEL - Particles of rock that pass a 3-in. (76.2 mm) sieve and are retained on a No. 4 (4.75 mm sieve).

GRAVITY - The force of attraction between bodies because of their mass. Usually measured as the acceleration of gravity.

GYPSIFEROUS - Containing gypsum, a mineral consisting mostly of sulfate of calcium.

HORST - An elongated crustal block that has been uplifted along faults relative to the rocks on either side.

INTERIOR DRAINAGE - Stream drainage system that flows into a closed topographic low (basin).

INTRUSIVE (rock) - A rock formed by the process of emplacement of magma (liquid rock) in preexisting rock, (e.g., granite, granodiorite, quartz monzonite).

LACUSTRINE DEPOSITS - Materials deposited in a lake environment.

LARAMIDE OROGENY - A time of deformation extending from late Cretaceous (about 100 million years ago) to the end of the Paleocene (about 50 million years ago) which accounted for much present Basin and Range structure.

LINE - A linear array of observation points, such as a seismic line.

GLOSSARY OF TERMS (Cont.)

LIQUID LIMIT - See ATTERBERG LIMITS.

LOW STRENGTH SURFICIAL SOIL - Soil which will perform poorly as a road subgrade, at its present consistency, when used dirctly beneath a road section.

MILLIGAL - A unit of acceleration used with gravity measurements; 1 milligal = 10^{-5} m/s^2. Abbreviated mgal.

MOISTURE CONTENT - The ratio, expressed as a percentage, of the weight of water contained in a soil sample to the ovendry weight of the sample.

NEOTECTONICS - The study of the recent structural history of the earth's crust, usually during the late Tertiary and the Quaternary periods.

N VALUE - Penetration resistance, described as the number of blows required to drive the standard split-spoon sampler for the second and third 6 inches (0.15 m) with a 140-pound (63.5-kg) hammer falling 30 inches (0.76 m) (ASTM D1586-67).

OPTIMUM MOISTURE CONTENT - Moisture content at which a soil can be compacted to a maximum dry unit weight by a given compactive effort.

P-WAVE - See Compressional Wave.

PATINA - A dark coating or thin outer layer produced on the surface of a rock or other material by weathering after long exposure (e.g., desert varnish).

PAVEMENT/DESERT PAVEMENT - When loose material containing pebble-sized or larger rocks is exposed to rainfall and wind action, the finer dust and sand are blown or washed away and the pebbles gradually accumulate on the surface, forming a mosaic which protects the underlying finer material from wind attack. Pavement can also develop in finer-grained materials. In this case, the armored surface is formed by dissolution and cementation of the grains involved.

PERMEABLE - The ability of liquid to pass through soil and/or rock material.

pH - An index of the acidity or alkalinity of a soil in terms of the logarithm of the reciprocal of the hydrogen ion concentration.

GLOSSARY OF TERMS (Cont.)

PHI (Ø) - Angle of internal friction.

PIEZOMETRIC SURFACE - An imaginary surface representing the static head of ground water and defined by the level to which water will rise in a well.

PITCHER TUBE SAMPLE - An undisturbed, 2.87-inch-(73-mm) diameter soil sample obtained from a drill hole with a Pitcher tube sampler. The primary components of this sampler are an outer rotating core barrel with a bit and an inner stationary, spring-loaded, thin-wall sampling tube which leads or trails the outer barrel drilling bit, depending upon the hardness of the material being penetrated.

PLASTIC LIMIT - See ATTERBERG LIMITS.

PLASTICITY INDEX - See ATTERBERG LIMITS.

PLAYA/PLAYA DEPOSITS - A term used in the southwest U.S. for a dried-up, flat-floored area composed of thin, evenly stratified sheets of clay, silt, or fine sand, and representing the lowest part of a shallow, completely closed or undrained, desert lake basin in which water accumulates and is quickly evaporated, usually leaving deposits of soluble salts.

POORLY GRADED - A descriptive term applied to a coarse-grained soil if it consists predominantly of one particle size (uniformly graded) or has a wide range of sizes with some intermediate sizes obviously missing (gap-graded).

RANGE-BOUNDED FAULT - Usually a normal fault in which one side has moved up relative to the other and which separates the mountain front from the valley.

RELATIVE AGE - The relationship in age (oldest to youngest) between geologic units without specific regard to number of years.

RESISTIVITY (True, Intrinsic) - The property of a material which resists the flow of electric current. The ratio of electric-field intensity to current density.

RESISTIVITY SOUNDING - Observation of electric fields caused by current introduced into the ground as a means of studying earth resistivity. Normally includes only those methods in which a very low frequency or direct current is used to measure apparent resistivity. "Sounding" implies that successive measurements are made with increased electrode spacing.

GLOSSARY OF TERMS (Cont.)

ROCK UNITS - Distinct rock masses with different characteristics (e.g., igneous, metamorphic, sedimentary).

ROTARY WASH DRILLING - A boring technique in which advancement of the hole through overburden is accomplished by rotation of a heavy string of rods while continuous downward pressure is maintained through the rods on a bit at the bottom of the hole. Water or drilling mud is forced down the rods to the bit, and the return flow brings the cuttings to the surface.

S-WAVE - See Shear Wave.

SAND - Soil passing through No. 4 (4.75 mm) sieve and retained on No. 200 (0.075 mm) sieve.

SAND DUNE - A low ridge or hill consisting of loose sand deposited by the wind, found in various desert and coastal regions and generally where there is abundant surface sand.

SEISMIC - Having to do with elastic waves. Energy may be transmitted through the body of an elastic solid as P-waves (compressional waves) or S-waves (shear waves).

SEISMIC LINE - A linear array of travel time observation points (geophones). In this study, each line contains 24 geophone positions.

SEISMIC REFRACTION DATA: deep/shallow - Data derived from a type of seismic shooting based on the measurement of seismic energy as a function of time after the shot and of distance from the shot, by determining the arrival times of seismic waves which have traveled nearly parallel to the bedding in high-velocity layers, in order to map the depth to such layers.

SEISMOGRAM - A seismic record.

SEISMOMETER - See Geophone.

SHEAR STRENGTH - The maximum resistance of a soil to shearing (tangential) stresses.

SHEAR WAVE - A body wave in which the particle motion is perpendicular to the direction of propagation. Also called S-Wave or transverse wave.

SHEET FLOW - A process in which stormborne water spreads as a thin, continuous veneer (sheet) over a large area.

GLOSSARY OF TERMS (Cont.)

SHEET SAND - A blanket deposit of sand which accumulates in shallow depressions or against rock outcrops, but does not have characteristic dune form.

SHOT - Any source of seismic energy; e.g., the detonation of an explosive.

SHOT POINT - The location of any source of seismic energy; e.g., the location where an explosive charge is detonated in one hole or in a pattern of holes to generate seismic energy. Abbreviated SP.

SILT - Fine-grained soil passing the No. 200 sieve (0.074 mm) that is nonplastic or very slightly plastic and that exhibits little or no strength when air-dried.

SILT SIZE - That portion of the soil finer than 0.02 mm and coarser than 0.002 mm.

SITE - Location of some specific activity or reference point. The term should always be modified to a precise meaning or be clearly understood from the context of the discussion.

SPECIFIC GRAVITY - The ratio of the weight in air of a given volume of soil solids at a stated temperature to the weight in air of an equal volume of distilled water at a stated temperature.

SPLIT-SPOON SAMPLE - A disturbed sample obtained with a split-spoon sampler with an outside diameter of 2.0 inches (5.1 cm). The sample consists of a split barrel which is driven into the soil using a drop hammer.

SPREAD - The layout of geophone groups from which data from a single shot are recorded simultaneously. Spreads containing 24 geophones have been used in Fugro's seismic refraction surveys.

STREAM CHANNEL DEPOSITS - See Fluvial Deposits.

STREAM TERRACE DEPOSITS - Stream channel deposits no longer part of an active stream system, generally loose, moderately well graded sand and gravel.

SULFATE ATTACK - The process during which sulfates, salts of sulfuric acid, contained in ground water cause dissolution and damage to concrete.

SURFICIAL DEPOSIT - Unconsolidated residual and alluvial deposits occurring on or near the earth's surface.

GLOSSARY OF TERMS (Cont.)

TEST PIT - An excavation made to depths of about 5 feet (1.5 m) by a backhoe. A test pit permits visual examination of undisturbed mate:ial in place.

TRENCH - An excavation by a backhoe to depths of about 15 feet (4.5 m). A trench permits visual examination of soil in place and evaluaton of excavation wall stability.

TRIAXIAL COMPRESSION TEST - A type of test to measure the shear strength of an undisturbed soil sample (ASTM D2850-70). To conduct the test, a cylindrical specimen of soil is surrounded by a fluid in a pressure chamber and subjected to an isotropic pressure. An additional compressive load is then applied, directed along the axis of the specimen called the axial load.

Consolidated-drained (CD) Test - A triaxial compression test in which the soil was first consolidated under an all-around confining stress (test chamber pressure) and was then compressed (and hence sheared) by increasing the vertical stress. Drained indicates that excess pore water pressures generated by strains are permitted to dissipate by the free movement of pore water during consolidation and compression.

Consolidated-undrained (CU) Test - A triaxial compression test in which essentially complete consolidation under the confining (chamber) pressure is followed by a shear at constant water content.

UNCONFINED COMPRESSION - A type of test to measure the compressive strength of an undisturbed sample (ASTM D2166-66). Unconfined compressive strength is defined as the load per unit area at which an unconfined prismatic or cylindrical specimen of soil will fail in a simple compression test.

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) - A system which determines soil classification for engineering purposes on the basis of grain-size distribution and Atterberg limits.

VALLEY FILL - See Basin-Fill Material/Basin-Fill Deposits.

VELOCITY - Refers to the propagation rate of a seismic wave without implying any direction. Velocity is a property of the medium and not a vector quantity when used in this sense.

VELOCITY LAYER - A layer of rock or soil with a homogenous seismic velocity.

GLOSSARY OF TERMS (Cont.)

VELOCITY PROFILE - A cross section showing the distribution of material seismic velocities as a function of depth and its configuration.

VERIFICATION SITE - A study area of approximately 200 to 400 mi^2 (520 to 1040 km^2) in which Verification Program activities are performed. The site is situated wholly within a larger Candidate Deployment Parcel (CDP).

WASH SAMPLE - A sample obtained by screening the returned drilling fluid during rotary wash drilling to obtain lithologic information between samples.

WATER TABLE - The upper surface of an unconfined body of water at which the pressure is equal to the atmospheric pressure.

WELL GRADED - A soil is identified as well graded if it has a wide range in grain size and substantial amounts of most intermediate sizes.

Definitions were derived from the following references:

American Society for Testing and Materials, 1976, Annual book of ASTM standards, Part 19: Philadelphia, American Soc. for Testing and Materials, 484 p.

Gary, M., McAfee, R., Jr., Wolf, C. L., eds., 1972, Glossary of geology: Washington, D.C., American Geol. Institute, 805 p.

Merriam, G., and Merriam, C., 1977, Webster's new collegiate dictionary: Springfield, Mass., G. and C. Merriam Co., 1536 p.

Sheriff, R. E., 1973, Encyclopedic dictionary of exploration geophysics: Tulsa, Oklahoma, Soc. of Exploration Geophysicists, 266 p.

A2.0 EXCLUSION CRITERIA

Table A2-1 lists the exclusion criteria applied during FY 79 Verification Studies. Many of the criteria have not significantly changed since Coarse Screening Studies. Most geotechnical criteria have been modified to accommodate the basing mode requirements of the hybrid trench and vertical shelter concepts as well as increasing levels of study detail.

CRITERIA		DEFINITION AND COMMENTS
SURFACE ROCK AND ROCK OCCURRING WITHIN 50 FEET (15m) AND 150 FEET (46m) OF THE GROUND SURFACE		Rock is defined as any earth material which is not rippable by conventional excavation methods. Where available, seismic P-wave velocities were evaluated in the determination of rock conditions.
SURFACE WATER AND GROUND WATER OCCURRING WITHIN 50 FEET (15m) AND 150 FEET (46m) OF THE GROUND SURFACE		Surface water includes all significant lakes, reservoirs, swamps, and major perennial streams. Water which would be encountered in a 50-foot and 150-foot excavation was considered in the application of this criterion. Depths to ground water resulting from deeper confined aquifers were not considered.
TOPOGRAPHIC	Percent Grade and Terrain	Areas having surface gradients exceeding 10 percent or a preponderance of slopes exceeding 10 percent as determined from maps at scales of 1:125 000, 1:62 500, and 1:24,000 and by field observation. Areas having drainage densities averaging at least two 10-foot deep drainages per 1000 feet (measured parallel to contours, as determined from maps at scales of 1:24,000 or in the field).
CULTURAL	Quantity/Distance:	Eighteen nautical mile exclusion arcs from cities having populations (1970) of 25,000 or more. Three nautical mile exclusion arcs from cities having populations (1970) of between 5,000 and 25,000.
	Land Use:	All significant federal and state forests, parks, monuments, and recreation areas. All significant federal and wildlife refuges, grasslands, ranges, preserves and management areas. Indian reservations.
	Economic:	High potential economic resource areas including oil and gas fields, strippable coal, oil shale, uranium deposits, and known geothermal resource areas (KGRA) of sufficient density so as to prohibit use as a viable siting area. Industrial complexes such as active mining areas, tank farms and pipeline complexes of sufficient density so as to prohibit use as a viable siting area.

EXCLUSION CRITERIA
VERIFICATION STUDIES, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE A2-1

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A3.0 ENGINEERING GEOLOGIC PROCEDURES

The principal objectives of the field geology investigation were to:

1. Delineate surficial extent of soil types and geologic units;
2. Assess terrain conditions; and
3. Make observations helpful in defining depth to rock and water.

Aerial photographs (1:60,000 black and white; 1:25,000 color) served as the base on which all mapping was done. Field activities were directed toward checking the photogeologic mapping.

Field checking consisted chiefly of collecting data about surficial soils at selected locations in order to refine contacts and defining engineering characteristics of photogeologic units. At each location, observations of grain size, color, clast lithology, surface soil development, and a variety of engineering parameters were recorded (see Section 1.0, Geotechnical Data). Observations were made in existing excavations (borrow pits, road cuts, stream cuts) or in hand-dug test pits. Extrapolation of this data to determine surficial extent was accomplished by geologic reconnaissance over existing roads.

Of the parameters listed, grain size is the most important for engineering purposes and for this reason is included in the geologic unit designation. However, grain size is not readily mapped on aerial photos, and much of the field work involved

determination of the extent of surficial deposits of a particular grain-size category (gravel, sand, or fine-grained).

Terrain data were also taken at all geologic field stations. Drainage width and depth were estimated and predominant surface slope was measured. Slopes were measured over a distance of 100 to 150 feet (31 to 46 m) with an Abney hand level. For additional data, depths of major drainages encountered during geologic reconnaissance between stations were recorded on aerial photos.

In order to help refine depth to rock interpretations, observations were concentrated along the basin margin to identify shallow rock. Rock samples were taken at the end points of DMA gravity profile lines to aid in gravity interpretations. Observations regarding depth to water were restricted to measurements in existing wells and borings.

A4.0 GEOPHYSICAL PROCEDURES

A4.1 SEISMIC REFRACTION SURVEYS

A4.1.1 Instruments

Field explorations were performed with a 24-channel SIE Model RS-44 seismic refraction system which consisted of 24 amplifiers coupled with a dry-write, galvanometer-type recording oscillograph. Seismic energy was detected by Mark Products Model L-10 geophones with natural frequency of 4.5 Hz. Geophones were fitted with short spikes to provide good coupling with the ground. Cables with two takeout intervals were used to transmit the detected seismic signal from the geophones to the amplifiers. Time of shot was transmitted from shotpoint to recording system via an FM radio link.

The degree of gain was set on the amplifiers by the instrument operators and was limited by the background noise at the time of the shot. The amplifiers are capable of maximum gain of 1.1 million. The oscillograph placed timing lines on the seismograms at 0.01-second intervals. The timing lines form the basis for measuring the time required for the energy to travel from the shot to each geophone.

A4.1.2 Field Procedures

Each seismic refraction line consisted of a single spread of 24 geophones with a distance of 410 feet (125 m) between end points. Geophone spacing provided six intervals of 25 feet (7.6 m) at both ends of the line and 11 central intervals of 10 feet (3 m). Six shots were made per spread at locations

65 feet (20 m), either 190 or 215 feet (58 or 66 m) and 305 feet 93 m) left and right of the spread center. The recording system was located between geophones 12 and 13.

The explosive used was "Kinestik" which was transported to the site as two nonexplosive components, a powder and a liquid. The components were mixed in the field to make an explosive compound. Charges ranged in size from one-third to five pounds and were buried from 1 to 5 feet (0.3 to 1.5 m) deep. Charges were detonated using Reynold's exploding bridge wire (EBW) detonators instead of conventional electric blasting caps. Use of EBWs provides maximum safety against accidental detonation and extremely accurate "time breaks" (instant of detonation). Relative elevations of geophones and shotpoints were obtained by level or transit where lines had more than 2 or 3 feet (0.6 to 0.9 m) of relief.

A4.1.3 Data Reduction

The travel times for compressional waves from the shots to the geophones were obtained from the seismograms by visual inspection. These times were plotted at their respective horizontal distances and best fit lines were drawn through the points to obtain apparent velocities for materials below the seismic line.

A combination of delay time and ray tracing methods was used in a computer program to obtain depth to refracting horizons from the time-distance information.

A4.2 ELECTRICAL RESISTIVITY SURVEYS

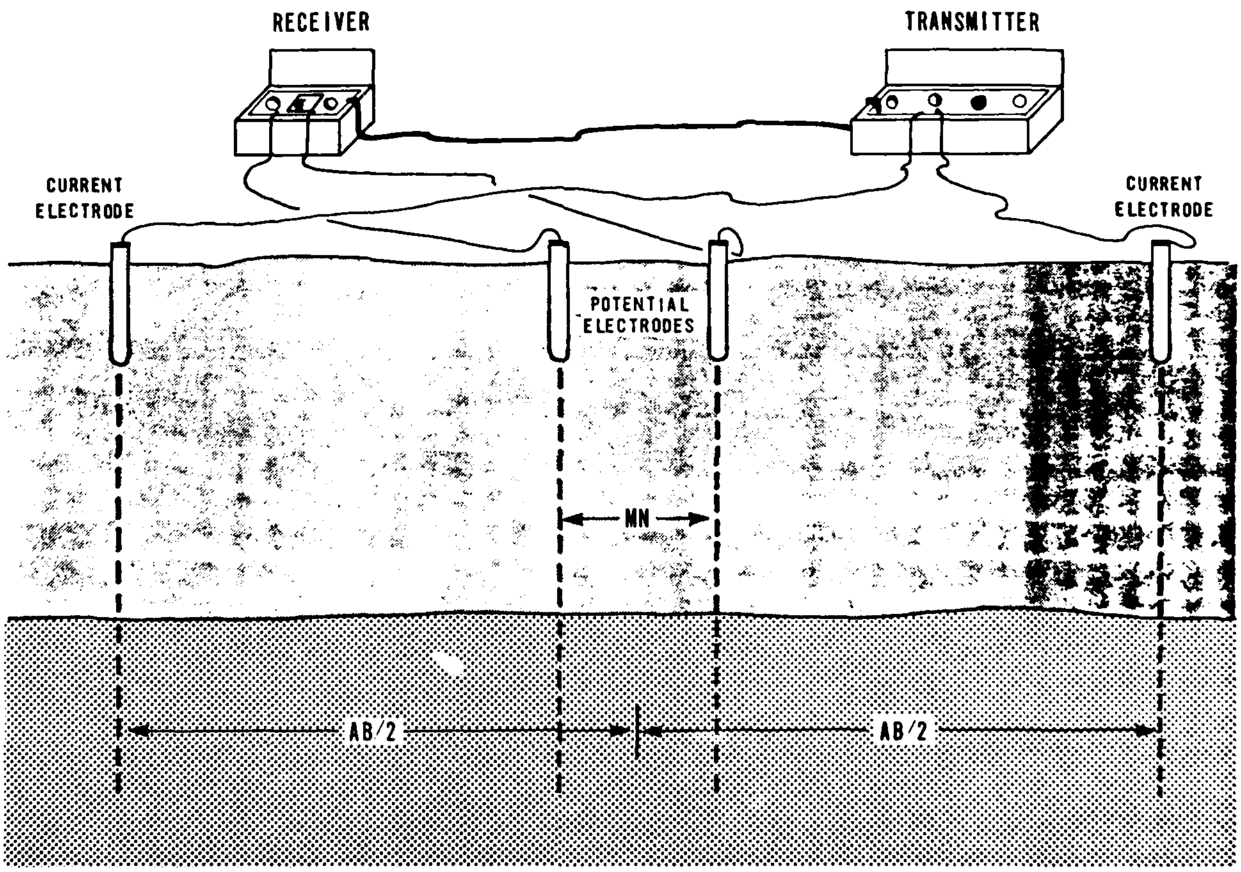
A4.2.1 Instruments

Elec+ric^l re-istivity measurements were made with a Bison Instrument model 235, B resistivity meter which provides current to the earth through two electrodes and measures the potential (voltage) drop across two other electrodes.

A4.2.2 Field Procedures

Electrical re^istivity soundings were made using the Schlumberger electrode arrangement. Soundings are made by successive resistivity measurements which obtain information from deeper and deeper materials. The depth of penetration of the electrical current is increased by increasing the distance between the current electrodes. The arrangement of electrodes in the Schlumberger method is shown in Figure A4-1. The four electrodes are in a line with the two current electrodes on the ends. The distance between the current electrodes (AB) is always five or more times greater than the distance between the potential electrodes (MN).

The initial readings are made with MN equal to 5 feet (1.5 m) and AB equal to 30 feet (9 m). Successive readings were made with AB at 40, 50, 60, 80, 100, 120, 140, 160, 180, 200, 240, 300, 360, 400, 500, and 600 feet (12, 15, 18, 24, 30, 37, 43, 49, 55, 61, 73, 91, 110, 122, 152, and 183 m). MN spacing is sometimes increased one or two times as AB is expanded. This increase is required when the signal drops to a level below the meter's sensitivity. The potential drop is greater between



SCHLUMBERGER ARRAY
ELECTRICAL RESISTIVITY SOUNDINGS
VERIFICATION SITES, ARIZONA

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	FIGURE A4-1

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more widely spaced electrodes (MN), so increasing MN increases the signal. When it becomes necessary to increase MN, the spacing of AB is reduced to the spacing of the previous reading. MN is then increased and a measurement is made. This provides two resistivity measurements at the same AB spacing but with different MN spacings.

A4.2.3 Data Reduction

Each apparent resistivity value is plotted versus one-half the current electrode spacing (AB/2) used to obtain it. Log-log graph paper is used to form the coordinates for the graph. A smooth curve is drawn through the points. This sounding curve forms the basis for interpreting the resistivity layering at the sounding location.

A computer program that does iterative "curve-matching" is used to develop a layer model that has a theoretical resistivity curve that is similar to the field curve. A Science Accessories Corporation "grafpen" digitizer is used to digitize the field curve for computer program input.

A4.3 GRAVITY

A4.3.1 General

A gravity survey involves determination of changes in the gravitational field between contiguous points. The gravitational field being detected is the same as that influencing all objects on the surface of the earth. It is generally associated with the force which causes a one-gm mass to be accelerated at 980 cm/s^2. This force is normally referred to as a 1-g force

In a gravity survey, the variations are measured in terms of milligals. A gal is equal to 1 cm/s^2 or 0.00102 g.

Small and distinguishable changes in gravity occur from point to point. These changes are caused by geometrical effects, such as differences in elevation and latitude, and by variations in density of the materials beneath the points. For measurements at the surface of the earth, the largest factor influencing the pull of gravity is the density of all materials between the center of the earth and the point of measurement. To detect the changes produced by differing geological conditions, it is necessary to detect changes in the gravitational field as small as a few milligals.

The basic concept of the gravitational exploration method is the "anomaly." If the earth were made up of uniform, concentric shells, each of uniform density, the gravitational field would be the same at all points on the surface of the earth. The fact that the pull of gravity is not the same from place to place gives rise to "anomalies." A difference in gravity between two points which is not caused by the effects of known geometrical differences, such as in elevation, latitude, and surrounding terrain, is referred to as an anomaly.

An anomaly reflects differences in material densities beneath the two points. The relationship is straightforward. The gravitational attraction is smaller at a place underlain by low-density material than it is at a place underlain by a high-density material. The term "negative gravity anomaly"

describes a situation in which the pull of gravity within a prescribed area is small compared to the area surrounding it. Low-density alluvial deposits in basins such as those in the Arizona study area produce negative gravity anomalies in relation to the gravity values in the surrounding mountains which are formed by more dense rocks.

The objective of gravity exploration is to deduce the variations in geologic conditions that produce the gravity anomalies identified during a gravity survey.

A4.3.2 Instruments

Lacoste and Romberg Model G gravimeters were used to measure the gravitational field. The sensing element is a mass suspended by a zero-length spring. Deflections of the mass from a null position are proportional to changes in gravitational attraction. The instrument is sealed and compensated for atmospheric pressure changes. It is maintained at a constant temperature by a heater element and thermostat. Gravitational changes as small as 0.01 milligal can be measured.

A4.3.3 Field Procedures

Gravimeter readings were taken at points on bedrock outcrops as well as points within the suitable area portions of the CDPs. Data were taken along lines extending across the CDPs. These lines or profiles were usually separated by 5 to 10 miles (8 to 16 km).

The gravimeter readings were calibrated in terms of absolute gravity by taking readings twice daily at nearby USGS gravity base stations. Gravimeter readings fluctuate because of small time-related deviations due to the effect of earth tides and instrument drift. Field readings were corrected to account for these deviations. The magnitude of the tidal correction was calculated using an equation suggested by Goguel (1954):

$$C = P + N\cos\phi\,(\cos\phi + \sin\phi) + S\cos\phi\,(\cos\phi - \sin\phi)$$

where C is the tidal correction factor, P, N, and S are time-related variables, and ϕ is the latitude of the observation point. Tables giving the values of P, N, and S are published annually by the European Association of Exploration Geophysicists.

The meter drift correction was based on readings taken at a designated base station at the start and end of each day. Any difference between these two readings after they were corrected for tidal effects was considered to have been the result of instrumental drift. It was assumed that this drift occurred at a uniform rate between the two readings. Corrections for drift were typically only a few hundredths of a milligal. Readings corrected for tidal effects and instrumental drift represented the observed gravity at each station. The observed gravity represents the total gravitational pull of the entire earth at the measurement station.

A4.3.4 Data Reduction

Several corrections or reductions were made to the observed gravity to isolate the portion of the gravitational pull which

is due to the crustal and near-surface materials located beneath the station. The gravity remaining after these reductions is called the "Bouguer Anomaly." Bouguer Anomaly values are the basis for geologic interpretation. To obtain the Bouguer Anomaly, the observed gravity was adjusted to the value it would have had if it had been measured at the geoid, a theoretically defined surface which approximates the surface of mean sea level. The difference between the "adjusted" observed gravity and the gravity at the geoid calculated for a theoretically homogeneous earth is the Bouguer Anomaly. Because the real earth, except for the upper mantle and crust, is thought to be similar to the homogeneous model, the Bouguer Anomaly is taken to indicate the way crustal materials differ from the model.

Four separate reductions, to account for four geometrical effects, were made to the observed gravity at each station to arrive at its Bouguer Anomaly value.

a. Free-Air Effect: Gravitational attraction varies inversely as the square of the distance from the center of the earth. Gravity measured at a greater distance from the center of the earth than the geoid is necessarily smaller than gravity on the geoid. Since the study area is above sea level, observed gravity levels were corrected for this difference using the normal vertical gradient of:

FA = -0.09406 mg/ft (-0.3086 milligals/meter)

where FA is the free-air effect. The free-air correction was positive in sign since the correction is opposite the effect.

b. Bouguer Effect: Like the free-air effect, the Bouguer effect is a function of the elevation of the station, but it considers the influence of a slab of earth materials between the observation point on the surface of the earth and the corresponding point on the geoid. Normal practice was followed in this study which is to assume that the density of the slab is 2.67 grams per cubic centimeter. The Bouguer correction (B_c), which is opposite in sign to the free-air correction, was defined according to the following formula.

$B_c = 0.01276\ (2.67)\ h_f$ (milligals per foot)

$B_c = 0.04185\ (2.67)\ h_m$ (milligals per meter)

where h_f and h_m is the height above sea level in feet or meters, respectively.

c. Latitude Effect: Points at different latitudes will have different "gravities" for two reasons. The earth (and the geoid) is spheroidal, or flattened at the poles. Since points at higher latitudes are closer to the center of the earth than points near the equator, the gravity at the higher latitudes is larger. As the earth spins, the centrifugal acceleration causes a slight decrease in gravity. At the higher latitudes where the earth's radii are smaller, the centrifugal acceleration diminishes. The gravity formula for the Geodetic reference system, 1967, gives the theoretical value of gravity at the geoid as a function of latitude. It is:

$g = 978.0381\ (1 - 0.0053204 \sin^2 \phi - 0.0000058 \sin^2 \phi)$ gals

where g is the theoretical acceleration of gravity and ϕ is the latitude in degrees. The positive term accounts for the

spheroidal shape of the earth. The negative term adjusts for the centrifugal acceleration.

The previous two corrections (free air and Bouguer) have adjusted the observed gravity to the value it would have had at the geoid. The theoretical value at the geoid for the latitude of the station is then subtracted from the adjusted observed gravity. The remainder is called the Simple Bouguer Anomaly (SBA). Most of this gravity represents the effect of material beneath the station, but part of it may be due to irregularities in terrain (upper part of the Bouguer slab) away from the station.

d. Terrain Effect: Topographic relief around the station has an effect on the gravitational force at the station. A nearby hill has upward gravitational pull and a nearby valley contributes no pull into a place where the Bouguer correction assumed there was mass to create a downward attraction. Therefore, relative to the SBA, the corrections are always positive. Corrections were made to the SBA when the terrain effects were 0.1 milligal or larger. Terrain corrected Bouguer values are called the Complete Bouguer Anomaly (CBA). When the CBA was obtained, the reduction of gravity at individual measurement points (stations) was complete.

A4.3.5 Interpretation

The first step in the interpretation was to separate the portion of the CBA that might be caused by the lightweight, basin-fill material overlying the heavier bedrock material which

forms the surrounding mountains and presumably the basin floor. In order to make this separation, the gravity field's appearance was postulated, assuming the valley-fill sediments were replaced with bedroc'. material. The imaginary field is called a "regional" and is characterized by a gently undulating (long period) surface. Since the valley-fill sediments were, in fact, absent at the stations read in the mountains, the CBA values at these bedrock stations were used as the basis for constructing a regional field over the valley. The "regional" was derived by fitting a second order polynomial surface to the Bouguer Anomaly values of the bedrock stations.

The difference between the CBA and the regional field was taken to represent the effect of the lightweight alluvial materials. This difference is called the residual field or residual anomaly. The zero value of the residual anomaly is not exactly at the rock outcrop line but at some distance on the "rock" side of the contact. The reason for this is found in the explanation of the terrain effect. There is a component of gravitational attraction from material which is not directly beneath a point.

If the "regional" is well chosen, the magnitude of the residual anomaly is a function of the thickness of the anomalous (fill) material and the density contrast. The density contrast is the difference in density between the alluvial and bedrock material. If this contrast were known, a very accurate calculation of the thickness could be made. In most cases, the densities are not well known and they also vary within the study area. In these

cases, it is necessary to use typical densities for materials similar to those in the study area. An iterative computer program was used to calculate a subsurface model which would yield a gravitational field to match (approximately) the residual gravity anomaly.

A5.0 ENGINEERING PROCEDURES

Soil engineering activities consisted of the following:

1. Field activities:
   - o Borings
   - o Trenches
   - o Test Pits
   - o Surficial Samples
   - o Cone Penetrometer Tests

2. Office activities:
   - o Laboratory Tests
   - o Data Analyses and Interpretations

In this section the procedures used in the various activities are described.

A5.1 BORINGS

A5.1.1 Drilling Equipment

The borings were drilled at designated locations using a truck-mounted Failing 1500 drilling rig with hydraulic pulldown and rotary wash techniques. Borings were nominally 4-7/8 inches (124 mm) in diameter and drilling fluid (typically a bentonite-water slurry) was used to stabilize the hole. A tricone drill bit was used for coarse-grained soils and a drag bit for drilling in fine-grained soils. Nominal maximum depth drilled was 160 feet (49 m).

A5.1.2 Method of Sampling Soil and Rock

A5.1.2.1 Sampling Intervals

Soil samples were obtained at the following nominal depths as well as at depths of change in soil type.

0'- 2'	(0-0.6 m)	- Drive sample
2.5'- 5'	(0.8-1.5 m)	- Pitcher or drive
6'- 8'	(1.8-2.4 m)	- Pitcher or drive
10'- 30'	(3.0-9.1 m)	- Pitcher or drive - samples at 5' intervals, starting at a depth of 10'
30'-130'	(9.1-39.0 m)	- Pitcher or drive - samples at 10' intervals
130'-160'	(39.0-48.0 m)	- Pitcher or drive - samples at 15' intervals

A5.1.2.2 Sampling Techniques

a. Fugro Drive Samples: Fugro drive samplers were used to obtain relatively undisturbed soil samples. The Fugro drive sampler is a ring-lined barrel sampler with an outside diameter of 3.0 inches (76.2 mm) and inside diameter of 2.50 inches (63.5 mm). It contains 12 individual 1-inch- (25.4-mm) long rings and is attached to a 12-inch- (30-cm) long waste barrel. The sampler was advanced using a downhole hammer weighing 335 pounds (76 kg) with a drop of 18 inches (46 cm).

The number of blows required to advance the sampler for a 6-inch (15-cm) interval were recorded. Samples obtained were retained in the rings, placed in plastic bags with manually twisted top ends and sealed in plastic sample containers. Each sample was identified with a label indicating job number, boring number, sample number, depth range, Unified Soil Classification System (USCS), and date. Ring samples were placed in foam-lined steel boxes.

b. Pitcher Samples: The Pitcher sampler was used to obtain undisturbed soil samples. The primary components of this sampler are an outer rotating core barrel with a bit and an inner, stationary, spring-loaded, thin-wall sampling tube which leads or trails the outer barrel drilling bit, depending on the hardness of the material penetrated. The average inside diameter of the sampling tubes used was 2.87 inches (73 mm). Before placing the Pitcher tube in the outer barrel, the tube was inspected for sharpness or protrusions.

The Pitcher sampler was then lowered to the bottom of the boring and the thin-walled sampling tube advanced into the soil ahead of the rotating cutting bit by the weight of the drill rods and hydraulic pulldown. The thin-walled sampling tube was retracted into the core barrel and the sampler was brought to the surface. After removal of the sampling tube from the core barrel, the length of the recovered soil sample was measured and recorded. Before preparing and sealing the tube, the drilling fluid in the Pitcher tube was removed. Cap plugs were taped in place on the top and bottom of the Pitcher tube and sealed with wax. When Pitcher samples could not be retrieved without disturbance, they were clearly marked as "disturbed." Each sealed Pitcher tube was labeled as explained under "Fugro Drive Samples" and then placed vertically in foam-lined wooden boxes.

c. Wash Samples: Wash samples (cuttings) were obtained by screening the returning drilling fluid during the drilling operations to obtain lithologic information between samples.

Recovered wash samples were placed in plastic bags and labeled as explained previously.

A5.1.3 Logging

All soils were classified in the field by the procedures outlined in Section A5.5, "Field Visual Soil Classification," of this Appendix. Rock encountered in the borings was described according to classifications given in Travis (1955) and Folk (1974). The following general information was entered on the boring logs at the time of drilling: boring number; project name, number, and location; name of drilling company and driller; name of logger and date logged; and method of drilling and sampling, drill bit type and size, driving weight and average drop as applicable. As drilling progressed, the soil samples recovered were visually classified as outlined in Section A5.5, "Field Visual Soil Classification," and the description was entered on the logs. Section A5.5 also discusses other pertinent data and observations made which were entered on the boring logs during drilling.

A5.1.4 Sample Storage and Transportation

Samples were handled with care, drive sample containers being placed in foam-lined steel boxes, while Pitcher samples were transported in foam-lined wooden boxes. Core samples were placed in specially constructed wooden or cardboard boxes. Particular care was exercised by drivers while traversing rough terrain so as not to cause any disturbance to the undisturbed samples. Whenever ambient air temperatures fell below 32°F, all samples were stored in heated rooms during the field work and

transported to Fugro National's Long Beach laboratory in heated cabins in back of pickup trucks.

A5.1.5 Ground-Water Observation Wells

When ground water was encountered during drilling of a boring or where the boring was located in an area estimated to have ground water within 150 feet (46 m) of the ground surface, the completed boring was cased with a 2-inch-diameter (51-mm) polyvinyl-chloride (PVC) pipe to 160 feet (49 m). This PVC pipe was slotted in the bottom 20 feet (6 m). After installation of the pipe, it was flushed until clear water came out. After equilibrium was reached, the water level was measured periodically in the observation wells and recorded.

A5.2 TRENCHES, TEST PITS, AND SURFICIAL SAMPLES

A5.2.1 Excavation Equipment

The trenches, tests pits, and surficial samples were excavated using a rubber tire-mounted Case 580 B or C backhoe with a maximum depth capability of 15 feet (5 m).

A5.2.2 Method of Excavation

Unless caving occurred during the process of excavation, the trench width was nominally 2 feet (0.6 m). Trench depths were typically 14 feet (4.2 m) and lengths ranged from 12 to 16 feet (3.6 to 4.9 m). Test pits were nominally 2 feet (0.6 m) wide, 5 feet (1.5 m) deep, and ranged from 5 to 10 feet (1.5 to 3.0 m) in length. Surficial sample excavations were typically 2 feet (0.6 m) wide, 2 feet (0.6 m) deep, and about 3 to 5 feet (0.9 to 1.5 m) long. The trench and test pit walls were vertical.

However, where surface materials were unstable, the trench walls were sloped back to a safe angle to prevent sloughing during the completion of excavation and logging. The excavated material was deposited on one side at least 4 feet (1.2 m) from the edge of the trenches in order to minimize stress loads at the edges. The excavations were backfilled with the excavated material and the ground surface was restored to a condition as conformable with the surrounding terrain as practical.

A5.2.3 Sampling

The following sampling procedures were generally followed for all trenches, test pits, and surficial samples.

- o Representative bulk soil samples (large or small) were obtained in the top 2 feet (0.6 m). If the soil type changed in the top 2 feet, bulk samples of both the soil types were obtained. In addition, bulk samples of all soil types encountered at different depths in the excavation were obtained. For each soil type in the top 2 to 3 feet (0.6 to 0.9 m), two large bulk samples (weighing about 50 pounds each; 11.4 kg) were taken. Bulk samples from other depths were limited to one bag. When soils from two locations were similar, only a small bag sample weighing about 2 pounds (1 kg) was taken from the second location.
- o All large bulk samples were placed first in plastic bags and then in cloth bags. The small bulk samples were placed in small plastic bags. All sample bags of soil were tied tightly at the top to prevent spillage and tagged with the

following information: project number; trench, test pit, or surficial sample number; bulk sample number; depth range in feet; Unified Soil Classification symbol; and date. The samples were transported to the field office for storage and then to Fugro National's Long Beach office in pickup trucks.

A5.2.4 Logging

The procedures for field visual classification of soil and rock encountered from the trenches, test pits, and surficial samples were basically the same as the procedures for logging of borings (Section A5.1.3). For excavations shallower than 4 feet (1.2 m) technicians entered the excavations and logged them. Logging of the excavations deeper than 4 feet (1.2 m) was accomplished from the surface and by observing the backhoe bucket contents. All trench walls were photographed prior to backfilling.

Each field trench, test pit, and surficial sample log included trench, test pit, or surficial sample number; project name, number and location; name of excavator; type of excavation equipment; name of logger; and date logged. As excavations proceeded, the soil types encountered were visually classified and described as outlined in Section A5.5, "Field Visual Soil Classification." Section A5.5 also discusses other pertinent data and observations made which were entered on the logs during excavation.

A5.3 CONE PENETROMETER TESTS

A5.3.1 Equipment

The equipment consisted of a truck-mounted (15 tons gross weight) electronic cone penetrometer equipped with a 10-ton cone (cone end resistance capacity of 10 tons) and 5-ton friction cone (1-1/2-ton limit on the friction sleeve and 5-ton limit on the cone end resistance). All operating controls, recorder, cables, and ancillary equipment were housed in the specially designed vehicle which was completely self-contained. The penetrometer, the key element of the system, contained the necessary load cells and cable connections. One end of the unit was threaded to receive the first sounding rod. When carrying out the tests, hollow rods with an outside diameter of 3.6 cm and a length of 1.0 meter were used to push down the cone. The hydraulic thrust system was mounted over the center of gravity of the truck, permitting use of the full 15-ton truck weight as load reaction.

The cone had an apex angle of 60° and a base area of 10 cm^2. The resistance to penetration was measured by a built-in load cell in the tip and was relayed to the surface recorder via cables in the sounding rods. On the 5-ton friction cone, a friction sleeve, having an area of 150 cm^2, was fitted above the cone base. The local friction was measured by load cells mounted in the friction sleeve and recorded in the same manner as the end resistance. The end resistance and friction resistance were recorded on a strip chart.

A5.3.2 Test Method

Tests were performed in accordance with ASTM D3441-75T, "Tentative Method for Deep, Quasi-Static, Cone and Friction-Cone Penetration Tests of Soil." Basically, the test was conducted by positioning the electronic cone penetrometer truck over the designated area for testing, setting the outriggers on the ground surface, checking the level of the rig, then pushing the cone into the ground at a rate of 2 cm/s until refusal (defined as the capacity of the cone, friction sleeve, or hydraulics system) or the desired depth of penetration was reached.

As a general rule, the depth of penetration did not exceed 10 meters. If refusal was reached within the top 2 or 3 feet (0.6 or 1 m), the test was performed again a few feet away from the first location. If refusal was reached again within 3 feet (1 m), the soil was excavated at the CPT location to investigate the presence of gravel, cobbles, boulders, or cemented layers. Details of the test such as refusal reached, depth, cone used, etc., were entered on a log sheet.

Generally, the 10-ton cone was used for most of the tests. If the measured cone resistance was less than 150 tons per square foot (147 kg/cm^2) in the upper 8 to 10 feet (2.4 to 3.0 m), then another test using the 5-ton cone was performed at a location a few feet away from the first location.

A5.4 FIELD VISUAL SOIL CLASSIFICATION

A5.4.1 General

All field logging of soils encountered during drilling, excavation of trenches and test pits, obtaining surficial samples, and the sampling at CBR test locations were performed in accordance with the procedures outlined in this section. Soil samples were visually classified in the field in general accordance with the procedures of ASTM D 2488-69, Description of Soils (Visual-Manual Procedure). The ASTM procedure is based on the Unified Soil Classification System (see Table A5-1) and details several visual and/or manual methods which can be used in the field to estimate the USCS soil group or symbol for each sample. Rock cores were described in the field according to classifications given in Travis (1955) and Folk (1974). The following section details several of the guidelines used in the field for describing soils, drilling and excavating conditions, and unusual conditions encountered.

A5.4.2 Soil Description

Soil descriptions entered on the logs of borings, trenches, test pits, and surficial samples generally included those listed below.

Coarse-Grained Soils

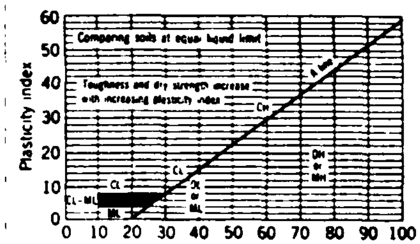
USCS Name and Symbol
Color
Range in Particle Size
Gradation (well, poorly)
Density
Moisture Content
Particle Shape
Reaction to HCl

Fine-Grained Soils

USCS Name and Symbol
Color
Consistency
Moisture Content
Plasticity
Reaction to HCl

Field Identification Procedures (Excluding particles larger than 3 in. and basing fractions on estimated weights)				Group Symbols[a]	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria	
Coarse-grained soils — More than half of material is *larger* than No. 200 sieve size[b] (The No. 200 sieve size is about the smallest particle visible to naked eye)	Gravels — More than half of coarse fraction is larger than No. 4 sieve size (For visual classification, the ¼ in. size may be used as equivalent to the No. 4 sieve size)	Clean gravels (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	*GW*	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name, indicate approximate percentages of sand and gravel, maximum size, angularity, surface condition, and hardness of the coarse grains, local or geologic name and other pertinent descriptive information, and symbols in parentheses	Use grain size curve in identifying the fractions as given under field identification. Determine percentages of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse grained soils are classified as follows: Less than 5% *GW, GP, SW, SP*; More than 12% *GM, GC, SM, SC*; 5% to 12% *Borderline* cases requiring use of dual symbols	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing	*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines			Not meeting all gradation requirements for *GW*
		Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)	*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures			Atterberg limits below "A" line, or *PI* less than 4 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures	For undisturbed soils add information on stratification, degree of compactness, cementation moisture conditions and drainage characteristics		Atterberg limits above "A" line, with *PI* greater than 7
	Sands — More than half of coarse fraction is smaller than No. 4 sieve size	Clean sands (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes	*SW*	Well graded sands, gravelly sands, little or no fines	Example: *Silty sand*, gravelly, about 20% hard, angular gravel particles ½-in. maximum size, rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength, well compacted and moist in place, alluvial sand, (*SM*)		$C_U = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing	*SP*	Poorly graded sands, gravelly sands, little or no fines			Not meeting all gradation requirements for *SW*
		Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)	*SM*	Silty sands, poorly graded sand-silt mixtures			Atterberg limits below "A" line or *PI* less than 4 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*SC*	Clayey sands, poorly graded sand-clay mixtures			Atterberg limits below "A" line with *PI* greater than 7

Fine-grained soils — More than half of material is *smaller* than No. 200 sieve size (The No. 200 sieve size is about the smallest particle visible to naked eye)	Identification Procedures on Fraction Smaller than No. 40 Sieve Size: Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)	Group Symbols[a]	Typical Names	Information Required for Describing Soils
Silts and clays liquid limit less than 50	None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses
	Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
	Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions
Silts and clays liquid limit greater than 50	Slight to medium	Slow to none	Slight to medium	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	
	High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays	Example: *Clayey silt*, brown, slightly plastic, small percentage of fine sand, numerous vertical root holes, firm and dry in place, loess, (*ML*)
	Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity	
Highly Organic Soils	Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils	



Plasticity chart for laboratory classification of fine grained soils

From Wagner, 1957.
[a] *Boundary classifications*. Soils possessing characteristics of two groups are designated by combinations of group symbols. For example *GW-GC*, well graded gravel-sand mixture with clay binder.
[b] All sieve sizes on this chart are U.S. standard.

Field Identification Procedure for Fine Grained Soils or Fractions

These procedures are to be performed on the minus No. 40 sieve size particles, approximately 1/64 in. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

Dilatancy (Reaction to shaking):
After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil soft but not sticky.
Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.
Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

Dry Strength (Crushing characteristics):
After removing particles larger than No. 40 sieve size, mould a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun or air drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.
High dry strength is characteristic for clays of the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

Toughness (Consistency near plastic limit):
After removing particles larger than the No. 40 sieve size, a specimen of soil about one-half inch cube in size, is moulded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eight inch in diameter. The thread is then folded and re-rolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.
After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.
The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.
Highly organic clays have a very weak and spongy feel at the plastic limit.

UNIFIED SOIL CLASSIFICATION SYSTEM

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DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE A5-1

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Some additional descriptions or information recorded for both coarse- and fine-grained soils included: degree of cementation, secondary material, cobbles and boulders, and depth of change in soil type.

Definitions of some of the terms and criteria used to describe soils and conditions encountered during the investigations follow.

a. USCS Name and Symbol: Derived from Table A5-1, the Unified Soil Classification System. The soils were first designated as coarse- or fine-grained.

Coarse-grained soils are those in which more than half (by weight) of the particles are visible to the naked eye. In making this estimate, particles coarser than 3 in. (76 mm) in diameter were excluded. Fine-grained soils are those in which more than half (by weight) of the particles are so fine that they cannot be seen by the naked eye. The distinction between coarse- and fine-grained can also be made by sieve analysis with the number 200 sieve (.074 mm) size particle considered to be the smallest size visible to the naked eye. In some instances, the field technicians describing the soils used a number 200 sieve to estimate the amount of fine-grained particles. The coarse-grained soils are further divided into sands and gravels by estimating the percentage of the coarse fraction larger than the number 4 sieve (about 1/4 inch or 5 mm). Each coarse-grained soil is then qualified as silty, clayey, poorly graded, or well graded as discussed under plasticity and gradation.

Fine-grained soils were identified in the field as clays or silts with appropriate adjectives (clayey silt, silty clay, etc.) based on the results of dry strength, dilatancy, and plastic thread tests (see ASTM D 2488-69 for details of these tests).

Dual USCS symbols and adjectives were used to describe soils exhibiting characteristics of more than one USCS group.

b. Color: Color descriptions were recorded using the following terms with abbreviations in parentheses:

White (w)	Green (gn)
Yellow (y)	Blue (bl)
Orange (o)	Gray (gr)
Red (r)	Black (blk)
Brown (br)	

Color combinations as well as modifiers such as light (lt) and dark (dk) were used.

c. Range in Particle Size: For coarse-grained soils (sands and gravels), the size range of the particles visible to the naked eye was estimated as fine, medium, coarse, or a combined range (fine to medium).

d. Gradation: Well graded indicates a coarse-grained soil which has a wide range in grain size and substantial amounts of most intermediate particle sizes. A coarse-grained soil was identified as poorly graded if it consisted predominantly of one size (uniformly graded) or had a wide range of sizes with some intermediate sizes obviously missing (gap-graded).

e. <u>Density or Consistency</u>: The density or consistency of the in-place soil was estimated based on the number of blows required to advance the Fugro drive or split-spoon sampler, the drilling rate (difficulty) and/or hydraulic pulldown needed to drill, visual observations of the soil in the trench or test pit walls, ease (or difficulty) of excavation of trench or test pit, or trench or test pit wall stability. For fine-grained soils, the field guides to shear strength presented below were also used to estimate consistency.

- Coarse-grained soils - GW, GP, GM, GC, SW, SP, SM, SC (gravels and sands)

Consistency	N-Value (ASTM D 1586-67), Blows/Foot
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	>50

- Fine-grained Soils - ML, MH, CL, CH (Silts and Clays)

Consistency	Shear Strength (ksf)	Field Guide
Very Soft	<0.25	Sample with height equal to twice the diameter, sags under own weight
Soft	0.25-0.50	Can be squeezed between thumb and forefinger
Firm	0.50-1.00	Can be molded easily with fingers
Stiff	1.00-2.00	Can be imprinted with slight pressure from fingers
Very Stiff	2.00-4.00	Can be imprinted with considerable pressure from fingers
Hard	Over 4.00	Cannot be imprinted by fingers

f. Moisture Content: The following guidelines were used in the field for describing the moisture in the soil samples:

Dry	:	No feel of moisture
Slightly Moist	:	Much less than normal moisture
Moist	:	Normal moisture for soil
Very Moist	:	Much greater than normal moisture
Wet	:	At or near saturation

g. Particle Shape: Coarse-grained soils

Angular	:	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	:	Particles are similar to angular but have somewhat rounded edges
Subrounded	:	Particles exhibit nearly plane sides but have well-rounded corners and edges
Rounded	:	Particles have smoothly curved sides and no edges

h. Reaction to HCl: As an aid for identifying cementation, some soil samples were tested in the field for their reaction to dilute hydrochloric acid. The intensity of the HCl reaction was described as none, weak, or strong.

i. Degree of Cementation: Based on the intensity of the HCl reaction and observation, the degree of cementation of a soil layer was described as weak to strong. Also, the following stages of development of caliche (cemented) profile were indicated where applicable.

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4 of 6

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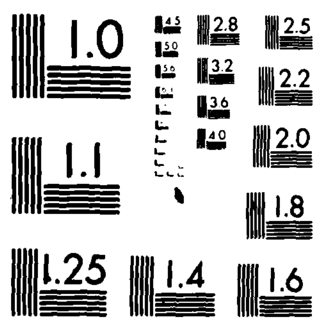


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

Stage	Gravelly Soils	Nongravelly Soils
I	Thin, discontinuous pebble coatings	Few filaments or faint coatings
II	Continuous pebble coatings, some interpebble fillings	Few to abundant nodules, flakes, filaments
III	Many interpebble fillings	Many nodules and internodular fillings
IV	Laminar horizon overlying plugged horizon	Increasing carbonate impregnation

j. Secondary Material: Example - Sand with trace to some silt

Trace	5-12%	(by dry weight)
Little	13-20%	(by dry weight)
Some	>20%	(by dry weight)

k. Cobbles and Boulders: A cobble is a rock fragment, usually rounded or subrounded, with an average diameter between 3 and 12 inches (76 and 305 mm). A boulder is a rock fragment, usually rounded by weathering or abrasion, with an average diameter of 12 inches (305 mm) or more. The presence of cobbles and/or boulders was identified by noting the sudden change in drilling difficulty or cuttings in borings or by visual observation in excavations. An estimate of the size, range, and percentage of cobbles and/or boulders in the strata was recorded on the logs.

l. Depth of Change in Soil Type: During drilling of borings, the depth of changes in soil type was determined by observing samples, drilling rates, changes in color or consistency of drilling fluid, and relating these to depth marks on the drilling rods. In excavations, strata thicknesses were measured with

a tape. All soil type interfaces were recorded on the logs by a horizontal line at the approximate depth mark.

In addition to the observations recorded relating to soil descriptions, remarks concerning drilling difficulty, loss of drilling fluid in the boring, water levels encountered, trench wall stability, ease of excavation, and other unusual conditions were recorded on the logs.

A5.5 LABORATORY TESTS

Laboratory tests were performed on selected representative undisturbed and bulk samples. All laboratory tests (except chemical tests) were performed in Fugro National's Long Beach laboratory. The chemical tests were conducted by Pomeroy, Johnson, and Bailey Laboratories of Pasadena, California. All tests were performed in general accordance with the American Society for Testing and Materials (ASTM) procedures. The types of tests performed and their ASTM designations are summarized as follows.

Type of Test	ASTM Designation
Unit Weight	D 2937-71
Moisture Content	D 2216-71
Particle-Size Analysis	D 422-63
Liquid Limit	D 423-66
Plastic Limit	D 424-59
Triaxial Compression	D 2850-70
Unconfined Compression	D 2166-66
Direct Shear	D 3080-72
Consolidation	D 2435-70
Compaction	D 1557-70
California Bearing Ratio (CBR)	D 1883-73
Specific Gravity	D 854-58
Water Soluble Sodium	D 1428-64
Water Soluble Chloride	D 512-67
Water Soluble Sulfate	D 516-68
Water Soluble Calcium	D 511-72
Calcium Carbonate	D 1126-67
Test for Alkalinity (pH)	D 1067-70

A5.6 DATA ANALYSIS AND INTERPRETATION

A5.6.1 Preparation of Final Logs and Laboratory and Field Test Summary Sheets

The field logs of all borings, trenches, test pits, and surficial sample excavations were prepared by systematically combining the information given on the field logs with the laboratory test results. The resultant logs include generally the following information: description of soil types encountered; sample types and intervals, lithology (graphic soil column); estimates of soil density or consistency; depth locations of changes in soil types; remarks concerning trench wall stability; drilling difficulty, cementation, and cobbles and boulders encountered; and the total depth of exploration. Laboratory test results presented in the logs include dry density and moisture content; percent of gravel, sand, and fines; and liquid limit and plasticity index. Also, miscellaneous information such as surface elevation, surficial geologic unit, date of activity, equipment used, and dimensions of the activity are shown on the log.

Laboratory data were summarized in tables. All samples which were tested in the laboratory were listed. Results of sieve analyses, hydrometer, Atterberg limits, in-situ dry strength and moisture content tests, and calculated de[illegible] of saturation and void ratio were entered on the tables. Test summary sheets for triaxial compression, unconfined compression, direct shear, consolidation, chemical, CBR, and compaction tests were prepared separately.

The Cone Penetrometer Test results consist of continuous plots of cone resistance and friction sleeve resistance (where friction cone was used), versus depth from ground surface. Beside the plot is shown a soil column with USCS soil types encountered at the test location. Other information presented on the log includes surface elevation and surficial geologic unit.

Separate volumes titled "Geotechnical Data" present the following finalized basic engineering data for each site.

Boring Logs	Section 6.0
Trench and Test Pit Logs	Section 7.0
Surficial Sample Logs	Section 8.0
Laboratory Test Results	Section 9.0
Field CBR Test Results	Section 10.0
Cone Penetrometer Test Results	Drawing 2

A5.6.2 Soil Characteristics

A5.6.2.1 General

The soil characteristics are discussed in two parts, surface soils and subsurface soils. The following three tables were prepared for each site and are presented in Sections 4.0 through 10.0 of the report.

1. Characteristics of Surficial Soils;
2. Thickness of Low Strength Surficial Soils; and
3. Characteristics of Subsurface Soils.

The following sections, A5.7.2.2 and A5.7.2.3, explain the data analyses and interpretation used in preparing the above tables.

A5.6.2.2 Surface Soils

In order to define the characteristics of the surficial soils, data from trenches, test pits, borings, surficial soil samples,

cone penetrometer tests, field CBR tests, and surficial geologic maps were reviewed in conjunction with the laboratory test results. The soils were then grouped into three or four categories of soils with similar general characteristics. These categories, their descriptions, and associated characteristics were tabulated for each site. These tables (Characteristics of Surficial Soils, Table X-2) include soil descriptions by the Unified Soil Classification System, predominant surficial geologic units, the estimated areal extent (percent) of each category, important physical properties summarized from laboratory test results, and certain road design related data.

The important physical properties summarized include the estimated cobble content, grain-size analyses, and Atterberg limits. Ranges for these properties were determined from the field logs and laboratory test results. These ranges are useful for categorizing soils, evaluating construction techniques, and providing data for preliminary engineering evaluations and for use by other MX participants.

Road design data presented in Table X-2 were developed from field and laboratory tests and consist of three distinct groups:

1. Laboratory test results;
2. Suitability of soils for road use; and
3. Low strength surficial soil.

These road design related data were considered important because roads (interconnecting and secondary) constitute a major portion of the geotechnically related costs for the vertical shelter

basing mode. The following paragraphs briefly discuss the development of road design data.

a. Laboratory Test Results: These include ranges of maximum dry density, optimum moisture content (ASTM D 1557-70), and CBR (ASTM D 1883-73) at 90 percent relative compaction for each soil category. The maximum dry density and optimum moisture content are important quality control parameters during roadway construction. California Bearing Ratio is the ratio of the resistance to penetration developed by a subgrade soil to that developed by a specimen of standard crushed-rock base material and is the basis for many empirical road design methods used in this country.

b. Suitability of Soils for Road Use: Included in this group is suitability of soils for use as road subgrade, subbase, or base. Parameters used to make these qualitative assessments were characteristics related to CBR, frost susceptibility, drainage, and volume change potential. The following guidelines were used in estimating the suitability of soils for road use:

1. Suitability as a road subgrade.

Very Good - soils which can be compacted with little effort to high CBR values (CBR >30), exhibit low frost susceptibility, fair to good drainage, and low volume change potential.

Good - soils which can be compacted with some effort to moderate CBR values (CBR 15-30), exhibit moderate frost susceptibility, fair drainage, and medium volume change potential.

Fair - soils which can be compacted with considerable effort to moderate CBR values (CBR 15-30),

exhibit moderate to high frost susceptibility, fair to poor drainage, and medium volume change potential.

Poor - soils which require considerable effort for compaction to even low CBR values (CBR <15), exhibit high frost susceptibility, poor drainage, or high volume change potential. These soils should generally be removed and replaced with better quality material.

2. Suitability as road subbase or base.

Good - soils which exhibit negligible frost susceptibility, good drainage, and negligible volume change potential.

Fair - soils which require some treatment or processing to upgrade for use.

Poor - soils which would require relatively extensive processing or soil stabilization to upgrade for use.

Not Suitable - soils which cannot be modified to give adequate roadway support.

The parameters used in the aforementioned suitability ratings are discussed in the following paragraphs.

i. CBR Characteristics: California Bearing Ratio, which is commonly used for road design, is dependent on soil type. A limited number of CBR tests were performed on several soil types which were representative of the surficial soils in the various Verification Sites. Based on these test results, a relationship between CBR and percent fines (percent passing through No. 200 sieve) was established and is shown in Figure A5-1. Envelopes for clays and granular soils with plastic fines and silts and granular soils with nonplastic fines are shown in the figure. This

plot was used to estimate the range of laboratory CBR values for the various surficial soil categories.

ii. Other Characteristics: These characteristics pertain to frost susceptibility, drainage, and volume change potential. They were estimated based on the physical properties of the soils, results of consolidation tests (for volume change potential), published literature, and our experience. Following are the definitions of these characteristics.

1. Frost susceptibility is defined as potential for detrimental ice segregation upon freezing or loss of strength upon thawing.

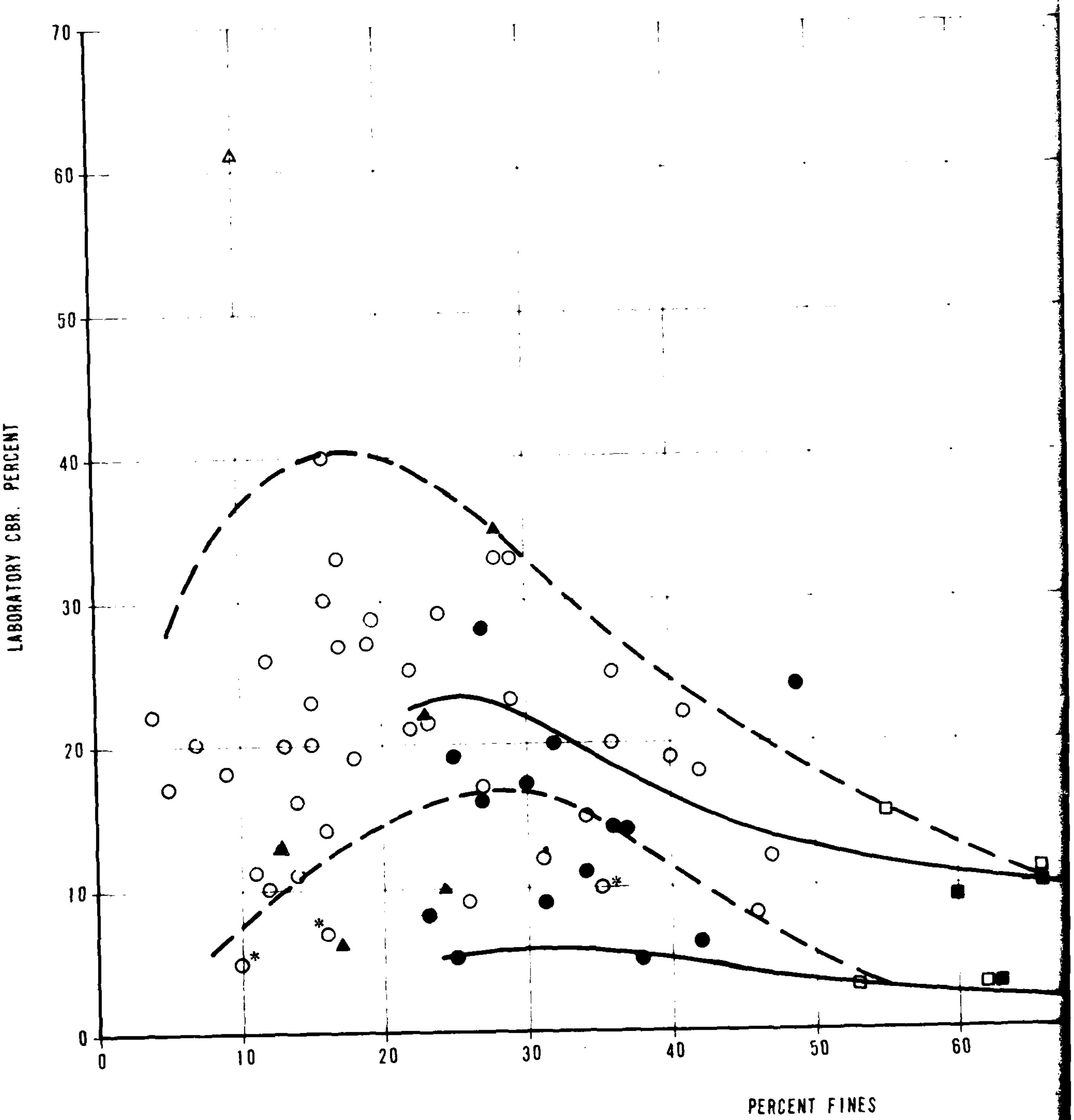
Low	- negligible to little potential
Moderate	- some potential
High	- considerable potential

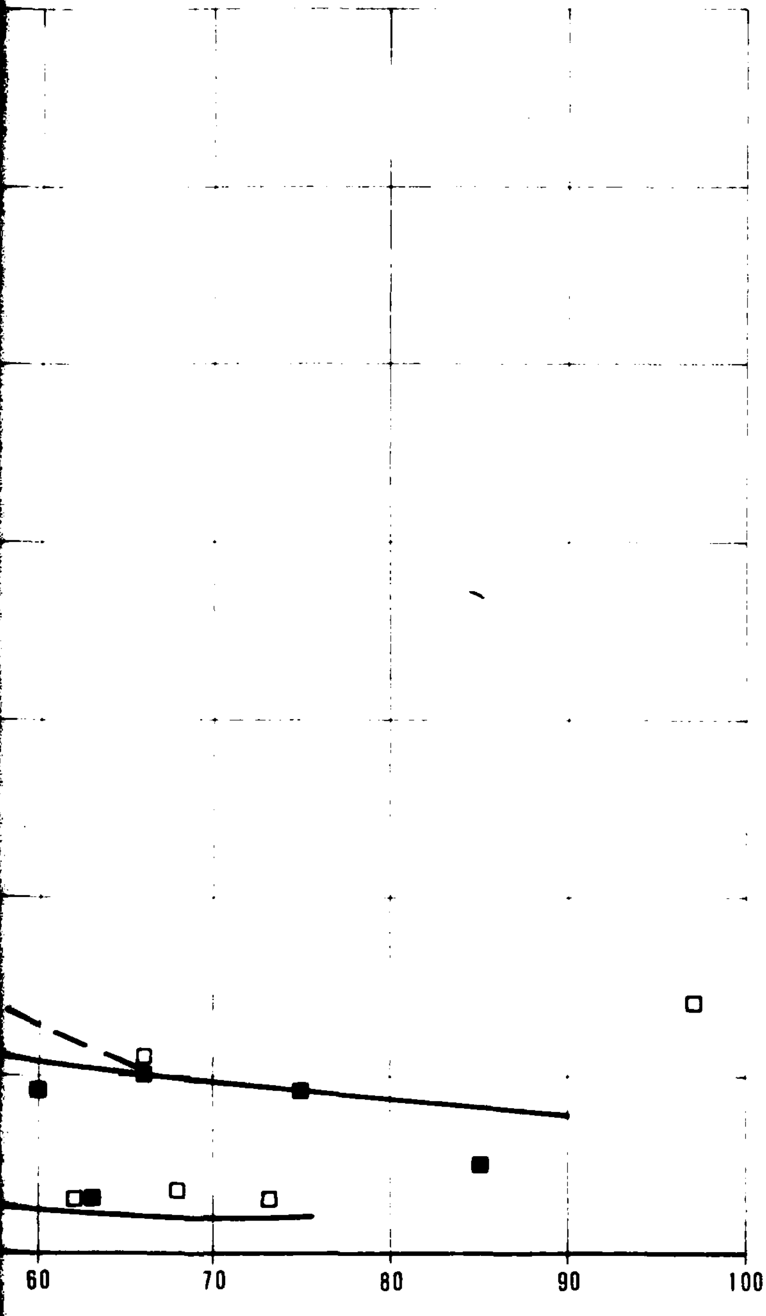
2. Drainage characteristics pertain to internal movement of water through soil.

Good	- materials which drain rapidly and do not tend to plug with fines
Fair	- natural internal drainage is fairly rapid but there is some tendency for plugging of voids with fines
Poor	- internal drainage is somewhat slow and plugging with fines can often occur
Practically Impervious	- materials which exhibit almost no natural internal drainage

3. Volume change potential corresponds to soil swelling or shrinkage due to change in moisture content.

Low	- 0 to 2 percent volume change
Medium	- 2 to 4 percent volume change
High	- > 4 percent volume change


LABORATORY CBR, PERCENT
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
PERCENT FINES



EXPLANATION

- △ Gravels with nonplastic fines (GM, GW, GP, GP-GM, GW-GM)
- ▲ Gravels with plastic fines (GC, GC-GM)
- ○ Sands with nonplastic fines (SP, SW, SM, SP-SM, SW-SM)
- ● Sands with plastic fines (SC, SC-SM)
- □ Silts (ML)
- ■ Clays (CL, CH, CL-ML)
- Dashed line: Envelope for silts and granular soils with nonplastic fines
- Solid line: Envelope for clays and granular soils with plastic fines

NOTES.

1. Fines correspond to soil passing through No 200 (0 074mm opening) sieve
2. California Bearing Ratio at 90 relative compaction
3. Soil types (GM, SC) are based on Unified Soil Classification System.
4. *Uniform fine or fine to medium sand.

PLOT OF LABORATORY CBR VERSUS PERCENT FINES VERIFICATION SITES, NEVADA-UTAH AND ARIZONA	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE SAMSO	FIGURE A5-1

FUGRO NATIONAL, INC.

2

c. <u>Low Strength Surficial Soil</u>: Included in this group is extent of low strength surficial soil. The roads for the MX system will be built on existing ground surface with minimum cut and fill. Therefore, the costs of roads depend on the consistency (or strength) of the surficial soil. In order to evaluate the strength of the surficial soils, cone penetrometer test results were used.

Low strength surficial soil is defined as soil which will perform poorly (failure of subgrade) as a road subgrade at its present consistency when used directly beneath a road section. In order to define "low strength" using CPT results, the following four approaches were pursued. These approaches are subjective and qualitative and are based on our experience as well as published literature.

i. <u>Field visual observations</u>: During logging of the borings, the excavation of trenches, test pits, and obtaining surficial soil samples, consistency or compactness of the surficial soils was described qualitatively. A detailed comparison of the CPT results (cone end resistance) and the consistency of the soils was done for different soil types. Using engineering judgement, an upper limit cone resistance was established which encompassed a majority of the soils likely to perform poorly as road subgrades.

ii. <u>Standard Penetration Test (SPT)</u>: SPT is very widely used and accepted in geotechnical engineering practice in this country. A study of available literature revealed that

the ratio of cone resistance (q_c, tsf) to Standard Penetration Resistance (N, blows per foot) has a certain range for different soil types. During Nevada-Utah Verification studies, limited field SPTs were performed in Reveille-Railroad and Big Smoky sites. Ratios of q_c/N were computed for these tests and were found to be comparable to those reported in literature for similar soil types. Using the relationships applicable to the soils present in the Verification sites, an upper limit of cone resistance, equivalent to midrange of "medium dense" category, was established for defining the "low strength" of surficial soils.

iii. <u>In-Situ Dry Density</u>: A comparison was made between in-situ dry densities determined from Fugro Drive and Pitcher samples obtained from soil borings and CPT results at the same locations and depths. From this comparison, it was observed that identifiable trends do exist between cone resistance values and soil densities. An upper limit of cone resistance equivalent to midrange of "medium dense" category was established for defining the "low strength" of surficial soils.

iv. <u>Field CBR Tests</u>: Field CBR tests were performed during Nevada-Utah Verification studies in Reveille-Railroad and Big Smoky sites. The tests were conducted at depths ranging between 6 and 30 inches (15 and 60 cm) below ground surface. At each CBR test location, three Cone Penetrometer Tests were made. A plot of average field CBR

CBR and average cone resistance was prepared and is presented in Figure A5-2. The plot shows the results of the tests in sands only, since tests in gravel and fine-grained soils were very few. Although there is considerable scatter, majority of the data points fall in a band which is shown in Figure A5-2. From this plot, a range of CPT resistance corresponding to low field CBR values (indicating low strength surficial soils) was established.

As a result of the preceding four approaches, the following criteria for defining low strength surficial soil were established:

q_c <120 tsf (117 kg/cm^2) for coarse-grained soils

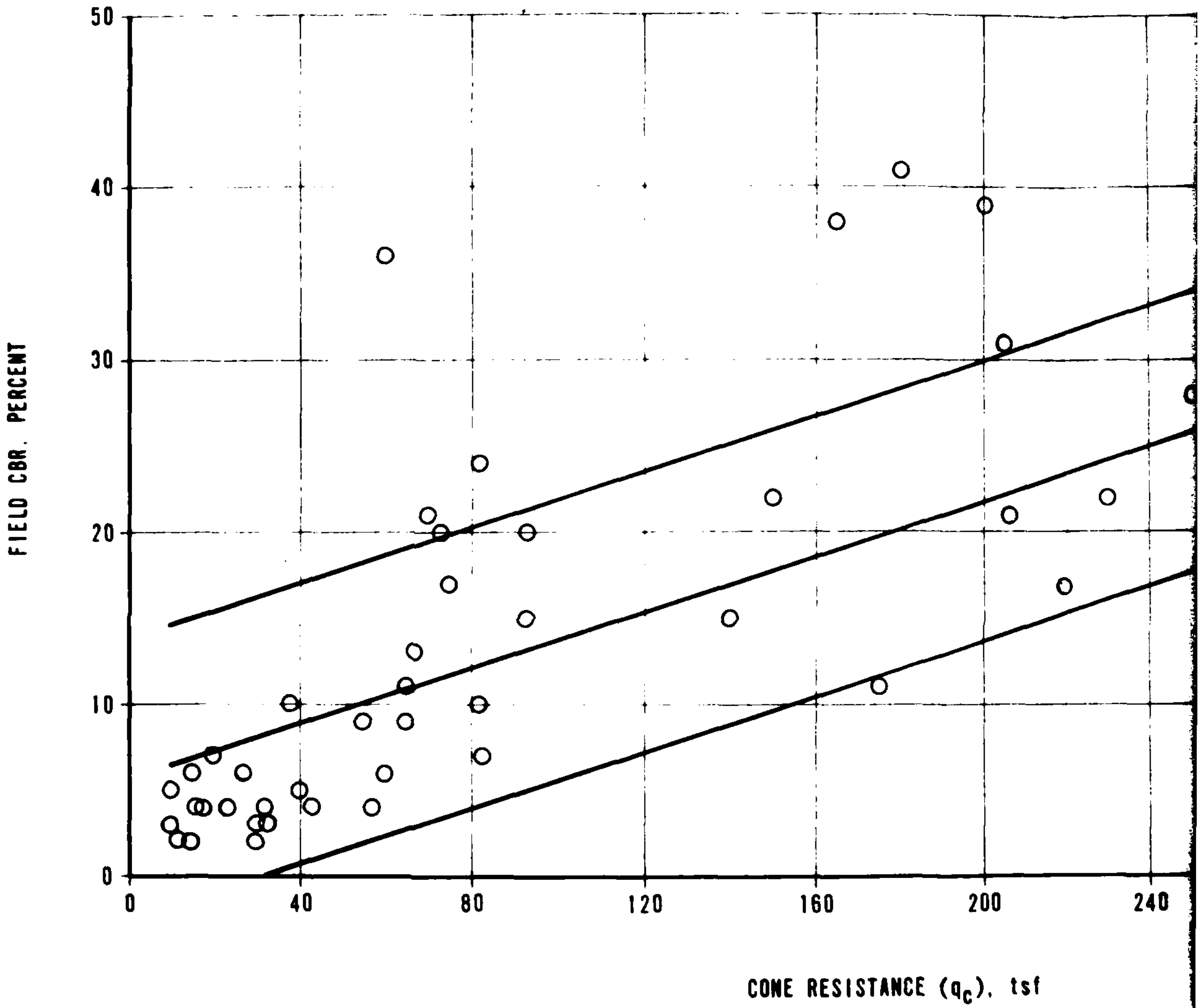
q_c < 80 tsf (78 kg/cm^2) for fine-grained soils

These criteria are preliminary at this stage and may be revised as more data become available from future verification studies.

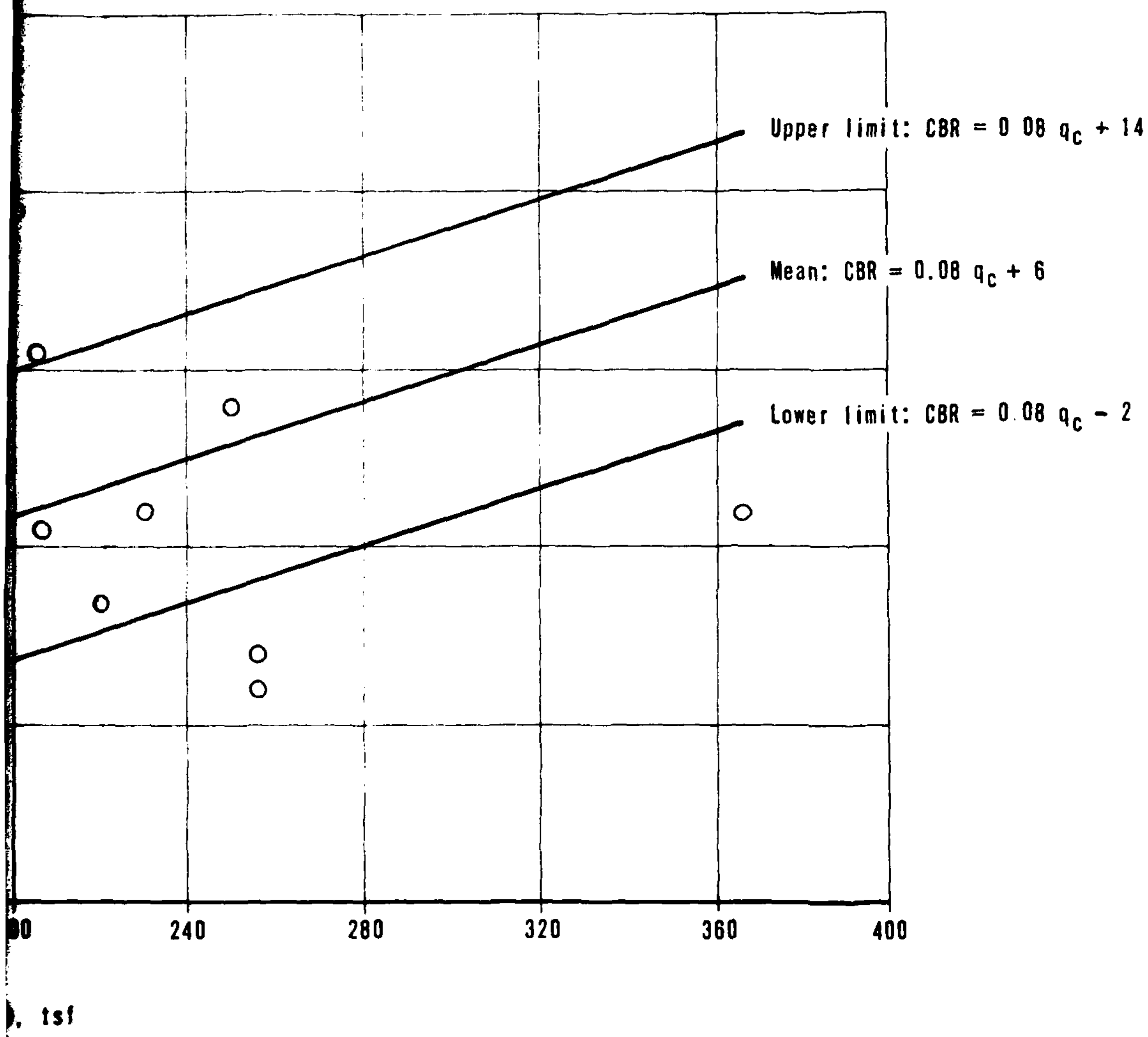
The criteria were used to determine the extent of low strength surficial soil at each CPT location. The results are tabulated in tables titled "Thickness of Low Strength Surficial Soil."

A5.6.2.3 Subsurface Soils

Characteristics of the subsurface soils were developed using data from seismic refraction surveys, borings, trenches, test pits, and laboratory tests. It should be emphasized that the data base for characteristics of subsurface soils is very limited since the total number of activities extending below 5 feet (1.5 m) was generally about 10 (5 borings and 5 trenches) in an area greater than 250 mi^2 (647 km^2).



NOTES:
1. Data are for sands tested in Big Smoky and Reveille-Railroad Verification Sites.
2. Equations shown are based on statistical analysis using standard error of estimate method.
3. Band between the upper and lower limits includes 74% of all the data points.



RELATIONSHIP BETWEEN FIELD CBR
AND CPT CONE RESISTANCE (q_c)
VERIFICATION SITES
REVEILLE-RAILROAD AND BIG SMOKY CDPs, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE
A5-2

FUGRO NATIONAL, INC.

The soils were divided into coarse-grained and fine-grained soils in two ranges of depth, 0 to 20 feet and 20 to 160 feet (0 to 6 m and 6 to 49 m). Physical and engineering properties of the soils were then tabulated as "Characteristics of Subsurface Soils" based on laboratory test results on representative samples. The tables include soil descriptions, Unified Soil Classification System symbols, the estimated subsurface extent of each soil group, comments on the degree of cementation, estimated cobbles content, and ranges of values from the following laboratory tests: dry density, moisture content, grain-size distribution, liquid limit, plasticity index, unconfined compression, triaxial compression, and direct shear.

The excavatability and stability of vertical excavation walls of a trench or a vertical shelter were evaluated from the subsurface data using seismic velocities, soil types, shear strength, presence of cobbles and boulders, and cementation. Problems encountered during trench and test pit excavations and drilling of borings were also considered in the evaluation.

VOLUME I
GEOTECHNICAL DATA, LA POSA CDP

TABLE OF CONTENTS

SECTION 1.0

GEOLOGIC STATION DATA

EXPLANATIONS OF GEOLOGIC STATION DATA

Geologic stations were established at selected locations throughout the CDP at which detailed descriptions of surficial basin-fill deposits or rock were recorded. Locations of all geologic stations are shown in Drawing 1, Activity Location Map. All data taken on surficial basin-fill units at these stations are listed in Table 1-1 and an explanation of the column headings in the table is given below. At stations where rock descriptions were made, only geologic unit designations are listed. A general explanation of all geologic unit symbols used in Verification Studies is included at the end of this section.

Column Heading Table 1-1	Explanation
Station Number	Geologic stations are numbered sequentially. Where more than one geologic field team worked in a CDP, stations made by each team are differentiated with a letter (A, B, or C) following the station number.
Geologic Unit	Generic geologic unit only, i.e. the grain-size designation (f, s, g, c) is omitted from surficial basin-fill units. The letter B in the unit designation indicates a buried deposit not exposed at the surface.
MPS MM	Average maximum particle size in millimeters.
Grain Size (%B, %C, %G, %S, %F)	Estimated particle size distribution using the Unified Soil Classification System. Percentages of boulders (%B) and cobbles (%C) are based on the entire deposit, whereas percentages of gravel (%G), sand (%S) and fines (%F) are taken only on the fraction composed of particles less than 3 inches (76 mm) in diameter.
USCS	Soil class according to the Unified Soil Classification System.

Munsell Color	Soil color based on Munsell Soil Color Chart.
Source Rock Types(s)	Rock types of coarse clasts listed in order of abundance.
* Physical Properties	Data listed in columns 6 through 15 address specific soil properties. These are listed below in parentheses following the column heading number and are also listed at the bottom of Table 1-1. Data are coded with each numerical entry referring to a specific soil condition as listed below.

6	(Grain Shape)	1) Angular, 2) Subangular, 3) Subrounded, 4) Rounded, 5) Well rounded
7	(Moisture Content)	1) Dry, 2) Moist, 3) Wet
8	(Plasticity of Fines)	1) None, 2) Low, 3) Medium, 4) High
9	(Consistency)	Coarse grained: 1) Very Loose, 2) Loose, 3) Medium Dense, 4) Dense, 5) Very Dense, Fine grained: 1)Soft, 2) Firm, 3) Stiff, 4) Hard
10	(Structure)	1) Stratified Tabular, 2) Stratified Other (lensed, cross bedded, discontinuous beds), 3) Nonstratified
11	(Cementation Induration)	1) None, 2) Weak, 3) Moderate, 4) Strong
12	(Depth to Cemented Layers)	Depth to layer (in centimeters) exhibiting cementation induration described in Column 11 (above)
13	(Weathering of clasts)	1) Fresh, 2) Slight, 3) Moderate, 4) Very
14	(Soil Profile Development)	1) None (A-C profile), 2) Poor (incipient B-horizon), 3) Well (prominant B-horizon)
15	(Caliche Development)	1) Stage I, 2) Stage II, 3) Stage III, 4) Stage IV, 5) None

Drainage

DP (M)	Average depth of drainages (in meters)
WD (M)	Average width of drainages (in meters)
Slope (%)	Average slope of ground surface (in percent grade)
Sample	Number of samples taken

GENERALIZED GEOLOGIC UNITS

Explanation

Surficial Basin-fill Units

A1 Younger Fluvial Deposits - Major modern stream channel and flood-plain deposits.

A2 Older Fluvial Deposits - Older incised stream channel and flood-plain deposits in elevated terraces bordering major modern drainages.

A3 Eolian Deposits - Wind-blown deposits of sand occurring as either thin sheets (A3s) or dunes (A3d).

A4 Playa and Lacustrine Deposits - Deposits occurring in modern, active playas (A4) or in either inactive playas or older lake beds and abandoned shorelines associated with extinct lakes (A4o).

A5 Alluvial Fan Deposits - Alluvial deposits consisting of debris flow and water-laid alluvium near mountain fronts, grading into predominantly water-laid alluvium deposited in shifting distributary channels near the basin center. Younger (A5y), intermediate (A5i), and older (A5o) alluvial fans are differentiated by surface soil development, terrain conditions, and present depositional/erosional environment.

Grain sizes of these deposits (except A3 deposits, which are exclusively sandy) are indicated by a single letter (f, s, g, or c) following the geologic unit symbol. These letters indicate the predominant grain size and range of soil types according to the Unified Soil Classification System:

f - fine-grained (ML, CL, MH, CH)

s - sands (SP, SW, SM, SC)

g - gravels (GP, GW, GM, GC)

c - coarse grained with greater than 30 percent boulders and cobbles (generally GP, GW, GM, GC)

ROCK UNITS

I Igneous (undifferentiated). Rocks formed by solidification of a molten or partially molten mass.

I1 Intrusive - Plutonic rocks formed by solidification of molten material beneath the surface (e.g., granite, granodiorite, diorite, gabbro).

I2 Extrusive (intermediate and acidic) - Volcanic rocks of intermediate and acidic compositon formed by solidification of molten material at or near the surface, (e.g., rhyolite, latite, dacite, andesite).

I3 Extrusive (basic) - Volcanic rocks of basic composition, generally formed by solidification of molten materials at or near the surface (e.g., basalt).

I4 Extrusive (pyroclastic) - Rocks formed by accumulation of volcanic ejecta (e.g., ash, tuff, welded tuff, agglomerate).

S Sedimentary (undifferentiated) - Rocks formed by accumulation of clastic solids, organic solids and/or chemically precipitated minerals.

S1 Arenaceous and/or Siliceous Rocks - Composed of sand-size particles (e.g., sandstone, orthoquartzite) or of cryptocrystalline silica (e.g., opal, chert).

S2 Carbonate Rocks - Composed predominantly of calcium carbonate detritus or chemical precipitates (e.g., limestone, dolomite, chalk).

S3 Argillaceous Rocks - Composed of clay and silt-sized particles (e.g., siltstone, shale, claystone).

S4 Evaporite Rocks - Precipitated from solution as a result of evaporation (e.g., halite, gypsum, anhydrite, sylvite).

S5 Coarse Clastic Rocks - Composed of gravel sized or larger clasts (e.g., conglomerate, breccia).

M Metamorphic (undifferentiated) - Rocks formed through recrystallization in the solid state of preexisting rocks by heat and pressure (e.g., gneiss, schist, hornfels, metaquartzite).

SOIL DESCRIPTION   TESTS

STATION NUMBER	GEOL UNIT	MPS PM	MPS SH	GRAIN SIZE SC	SG	SS	SF	UCS	MUNSELL COLOR	SOURCE ROCK TYPE(S)	6	7	8	9	10	11	12	13	14	15	[illegible]	[illegible]	SALT (%)	[illegible]
ABUG01A	A5Y	030	00	00	0T	075	025	SM	07.5YR5/6	M	2	2	2	3	3	1		2	1	1	.8	001	01	1
ABUG01D	A5Y	090	00	05	25	045	025	SM	10.0YR5/4	M	2	1	2	4	3	2		2	1	1	.1	001	01	1
ABUG02A	A5Y	030	00	00	0T	070	030	SC	07.5YR5/6	M 11	2	2	2	3	3	1			1	4	.2	001	01	1
ABUG02B	A50	190	0T	10	60	025	005	GM-GM		11 M	2	1	1		3	2	000	2	1	2	5.0	004	02	1
ABUG03A	A5Y	060	00	00	05	070	025	SM	07.5YR5/6	M	2	2	2	3	3	1			1	4	.3	001	01	1
ABUG03B	A5Y	015	00	00	05	070	025	SC	07.5YR4/6	M	3	3	3	4	3	1		1	1	1	.1	001	01	1
ABUG04A	A5I	140	0T	05	25	067	003	SM		M 11	2	1	1	1	2	2	00[illegible]	2	1	1	5.0	175	02	1
ABUG04F	A3L	001	00	00	00	100	00T	SM	07.5YR4/4		2	1	1	2	3	1			1	4				1
ABUG05A	A5I	100	00	05	30	045	025	SC	07.5YR4/4	M	3	2	2	4	4	1		4	1	2	2.0	010	01	1
ABUG05H	A5Y	040	00	00	0T	075	025	SM	10.0YR4/6	M	2	2	1	3	3	1		2	1	1	.1	001	01	1
ABUG06A	A50	250	0T	10	55	025	025	GM		M	2	1	2	4	2	2	020	3	2	3	6.0	002	01	1
ABUG06B	A5I	150	0T	05	50	035	010	GM-GM		M	2	1	1	4	4	1		2	1	4	2.5	008	01	1
ABUG07A	A40	001	00	00	00	000	100	CL				1	3	4	1	1			1	5				1
ABUG07B	A5I	090	00	00	25	065	010	SM-SM	10.0YR6/4	M		2	1	3	3	1		2	2	1	1.5	001	01	1
ABUG08A	A5Y	080	00	0T	05	085	010	SP-SM	10.0YR4/4	11	2	2	1	2	2	1		2	1	5	1.0	010	01	1
ABUG08B	A5Y	070	00	00	40	050	010	SP-SM	10.0YR4/4	M	3	2	1	3	2	2	066	2	1	1	.8	002	01	1
ABUG09A	A5I	110	00	05	05	070	025	SM	07.5YR5/6	M 12 11	2	2	1	3	3	2	040	2	1	2	1.5	010	02	1
ABUG09B	A5I	080	00	00	20	060	020	SM	07.5YR4/4	M	2	1	2	3	2	2	045	2	1	2	.5	001	02	1
ABUG10A	A40																							
ABUG10B	S5																							
ABUG11A	A5I	110	00	0T	65	025	010	GM-GP		M 11 12	3	1	1	2	3	2	011	2	1	1	3.0	001		
ABUG11B	A5Y	080	00	0T	55	035	010	GM-GP		M	2	1	1	3	3	1		2	1	5	.2	001	01	1
ABUG12A	A50	100	00	0T	17	080	010	SM-SP	05.0YR5/6	12 11	3	1	1	4	2	2	030	2	1	3	4.0	002		1
ABUG13A	A5I	007	00	00	00	085	015	SM	05.0Y 7/3	11	2	1	1	4	3	2	025		1	5	2.0	080		1
ABUG14A	A5I	053	00	00	10	080	010	SM	10.0YR5/3	11 12 M	2	1	1	3	2	1		4	1	5	3.0	075		1
ABUG15A	A5I	030	00	00	0T	075	025	SM	10.0YR5/4	12 11 M	2	1	1	4	3	2	013		1	1	1.5	020	02	1
ABUG16A	A5T	092	00	0T	05	075	020	SM	07.5YR4/6	11 M 12	2	1	1	3	3	4	055	2	1	3	5.0	040	01	1
ABUG17A	A5Y	050	00	00	0T	080	020	SM	10.0YR4/4	11 12 M	2	2	1	2	3	1		2	1	5	.2	001	04	0
ABUG18A	A5Y	010	00	00	00	075	025	SM	10.0YR4/4	11 12	2	2	1	2	3	1			1	5	.0	000	01	1
ABUG19A	A40																							
ABUG20A	A5I	083	00	0T	05	090	005	SP	07.5YR5/6	12 11	3	1	1	2	2	1		2		5	6.0	040		
ABUG21A	A5Y	050	00	00	05	080	015	SM	07.5YR5/6	11 12	3	2	1	2	2	1		2	1	5	.4	001	01	1
ABUG22A	A5I	060	00	00	05	065	030	SM	07.5YR5/6	12 M 11 12	2	2	1	3	3	2	018	2	1	2	.2	001	01	1
ABUG23A	A5I	050	00	00	02	068	030	SM	07.5YR5/4	12 11 M	2	2	1	3	3	2	017	2	1	2	.5	038	02	1
ABUG24A	A5Y	002	00	00	00	070	030	SM	07.5YR5/6	12 11	2	2	1	2	3	1			1	5	.3	001	02	1
ABUG25A	A1	030	00	00	00	095	005	SP	10.0YR5/6	12 M 11	2	2	1	2	3	1		2	1	5	.5	030	01	1
ABUG26A	A5Y	093	00	05	35	055	010	SM	10.0YR4/4	M 12	2	2	1	2	3	1		2	1	4	.5	001	01	1
ABUG27A	A5I	120	0T	10	55	030	015	GM		M	1	1	1	4	3	2	040	2	1	2	6.0	040		1
ABUG28A	A5I	120	00	02	05	075	020	SM	07.5YR4/6	M 11	2	2	1	3	3	1		2	1	5	2.0	002		1
ABUG29A	A5I	095	00	0T	40	040	020	SM	07.5YR5/6	M 11	2	1	2	4	3	2	042	3	3	2	2.0	001	01	1
ABUG30A	A5Y	020	00	00	0T	080	020	SM	07.5YR4/6	M 11	2	2	2	3	2	1		2	1	5	.1	001	01	1
ABUG31A	A5Y	080	00	00	10	060	010	SP-SM	10.0YR4/6	M 11	2	2	1	3	2	1		2	1	4	.2	001	01	1
ABUG32A	A5I	100	00	0T	15	065	020	SM	07.5YR5/4	M 11	2	1	2	3	3	1		2	2	1	.5	001	01	1
ABUG33A	A5Y	035	00	00	0T	065	035	SM	07.5YR5/6	M 11	2	2	2	4	3	1		2	1	1	.3	001	01	1
ABUG34A	A5I	070	00	0T	55	025	020	GC	07.5YR4/6	M 11	2	1	3	3	3	2	000	2	2	2	1.0	001	01	1
ABUG35A	A5Y	075	00	0T	15	065	020	SM	07.5YR4/4	M	2	2	2	4	3	1		2	1	5	.5	001	01	1
ABUG36A	A5Y	025	00	00	00	080	020	SM	07.5YR5/4	M	2	2	1	3	3	1		2	1	5	.1	001	01	1
ABUG37A	A5Y	040	00	00	0T	060	040	SM	10.0YR5/6	M 11	2	2	3	3	3	1			1	1	.7	002	02	0
ABUG38A	A5I	090	00	0T	50	025	025	GM		M 11	2	2	2	3	3	2	056	3	2	3	1.0	002	02	0
ABUG39A	A5I	090	00	0T	15	065	020	SM	07.5YR5/4	M	2	1	2	3	3	2	080	2	2	1	7.0	002	02	0
ABUG40A	A5Y	080	00	00	05	075	020	SM	07.5YR4/4	M 11	2	2	1	3	3	1		2	1	4	.7	001	01	1
ABUG41A	A5I	100	00	0T	10	075	015	SM	10.0YR3/6	M	2	2	1	3	3	1		2	2	1	.5	001	01	1
ABUG42A	A5Y	150	00	10	45	050	005	SP-SM	10.0YR4/4	M 11	2	2	1	2	3	1		2	1	1	.8	001	01	1
ABUG43A	A5I	350	05	10	60	035	005	GP-GM		M	2	1	1	4	2	2	016	2	3	3	4.0	025	04	1
ABUG44A	A5Y	030	00	00	0T	080	020	SM	10.0YR4/6	M	2	2	1	3	3	1		2	1	5	.2	001	01	1
ABUG45A	A5I	120	00	05	10	060	025	SM	10.0YR5/6	M	2	2	2	3	3	2	040	2	2	3	.2	001	01	1
ABUG46A	A5I	100	00	0T	15	065	020	SM	10.0YR4/4	M	2	1	2	3	3	3	034	2	2	3	2.0	001	01	1
ABUG47A	A5Y	100	00	0T	15	070	015	SM	10.0YR4/3	M 11	2	2	1	3	2	1		2	1	1	.2	001	01	1
ABUG48A	A5I	050	00	00	55	025	020	GM		M 11	2	1	2	4	3	2	023	2	3	2	1.5	001	01	1
ABUG48A	A5B	060	00	00	05	060	035	SM	10.0YR5/4	M 11	2	2	2	3	3	1		2	1	1	1.5	001	02	1
ABUG49A	A5I	060	00	00	05	060	035	SM	10.0YR5/4	M	2	2	3	4	3	2	024	2	2	1	1.0	001	04	1
ABUG50A	A5I	110	00	0T	50	030	020	GC		M	2	1	3	3	3	2	026	2	1	2	1.0	001	04	0
ABUG51A	A5Y	080	00	0T	15	065	020	SM	10.0YR4/4	M	2	2	2	3	3	1		2	1	5	1.0	001		1
ABUG52A	A5I	100	0T	10	50	030	020	GM		M	2	1	2	3	3	1		2	1	1	2.0	002	01	1
ABUG53A	A50									M											45.0	002	10	
ABUG54A	A5Y	050	00	00	0T	095	005	SP-SP	10.0YR4/3	M	2	2	1	2	3	1		2	1	5	1.0	001	01	1
ABUG55A	A5I	060	00	00	10	065	025	SC	07.5YR4/6	M	2	1	3	4	3	2	022	2	3	3	2.0	001	01	1

*PHYSICAL PROPERTIES :
6 - GRAIN SHAPE
7 - MOISTURE CONTENT
8 - PLASTICITY FINES
9 - CONSISTENCY
10 - STRUCTURE
11 - CEMENTATION-INDURATION
12 - DEPTH TO CEMENTED LAYER(CM)
13 - WEATHERING OF CLASTS
14 - SOIL PROFILE DEVELOPMENT
15 - CALICHE DEVELOPMENT

GEOLOGIC STATION DATA
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 1-1

FUGRO NATIONAL, INC.

SECTION 2.0

GROUND WATER DATA

EXPLANATIONS OF GROUND-WATER DATA

Existing ground-water data in La Posa CDP were collected from all available sources. These data were updated where possible from measurements taken during Fugro field operations, and all data are shown in Table 2-1. Locations of water wells and boreholes in which water-level measurements were available are shown in Drawing 1. Well numbers listed in Column 1 (Table 2-1) refer to well locations in Drawing 1. Actual well numbers giving location according to the Bureau of Land Management Land Survey System are shown in Column 2.

Water levels generally refer to the static ground-water table in the unconfined basin-fill aquifer. Perched conditions or levels in artesian aquifers are noted where known.

WELL NO.	WELL LOCATION NUMBER*	ELEVATION OF GROUND SURFACE-FEET (METERS) ABOVE M.S.L.	DEPTH OF WELL-FEET (METERS)	WATER LEVEL DEPTH BELOW GROUND SURFACE-FEET (METERS)	WATER LEVEL DATE MEASURED	WATER LEVEL ELEVATION-FEET (METERS) ABOVE M.S.L.	REFERENCES**/ REMARKS
W1	(B-8-19) 34daa	609 (186)	-	-	-	-	1,2
W2	(B-7-17) 6bad	830 (253)	-	108 (33)	1975	722 (220)	4
W3	(B-7-17) 9cbd	779 (237)	158 (48)	112 (34)	1967	667 (203)	4
W4	(B-7-17) 9ddb	795 (242)	-	102 (31)	1975	693 (211)	4
W5	(B-7-19) 10d	830 (253)	1400 (427)	472 (144)	1968	358 (109)	5/Log
W6	(B-7-19) 24bab	860 (262)	2500 (762)	515 (157)	1968	345 (105)	5/Log
W7	(B-5-19) 2aaa	893 (272)	700 (213)	DRY	1974	-	2, 5
W8	(B-5-19) 32aac	726 (221)	44 (13)	35 (11)	1962	691 (211)	2
W9	(B-5-20) 8dcc	505 (154)	-	-	1967	-	4
W10	(B-4-19) 16adc	833 (254)	44 (13)	24 (7)	1969	809 (247)	2
W11	(B-4-19) 16bcd	833 (254)	-	31 (9)	1973	802 (244)	2
W12	(B-4-19) 16cac	838 (255)	65 (20)	35 (11)	1973	803 (245)	2
W13	(B-4-19) 22bca	868 (264)	90 (27)	56 (17)	1973	812 (248)	2
W14	(B-4-19) 22bcb	889 (271)	48 (15)	76 (23)	1973	813 (248)	2
W15	(B-4-19) 21caa	858 (262)	-	26 (8)	1973	832 (254)	1,2
W16	(B-4-19) 21dac	868 (265)	60 (18)	22 (7)	1973	846 (258)	2
W17	(B-4-19) 21ddb	877 (267)	62 (19)	27 (8)	1973	850 (259)	2

*Gila and Salt River Baseline and Meridian

**References
1) Metzger et. al. (1973)
2) U.S. Geological Survey (1975)
3) U.S. Geological Survey (1978a)
4) U.S. Geological Survey (1978b)
5) U.S. Geological Survey (1979)

NOTE: All wells tap unconfined alluvial aquifers except where noted. Where published data are lacking or inaccurate, ground surface elevations are taken from topographic maps.

GROUND WATER DATA
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 2-1
1 of 3

FUGRO NATIONAL, INC.

WELL NO.	WELL LOCATION NUMBER*	ELEVATION OF GROUND SURFACE-FEET (METERS) ABOVE M.S.L.	DEPTH OF WELL-FEET (METERS)	WATER LEVEL			REFERENCES**/ REMARKS
				DEPTH BELOW GROUND SURFACE-FEET (METERS)	DATE MEASURED	ELEVATION-FEET (METERS) ABOVE M.S.L.	
W18	(B-4-19) 23ccd	920 (280)	146 (44)	120 (37)	1962	800 (244)	2
W19	(B-4-19) 27cdd	918 (280)	-	97 (30)	1973	821 (250)	2
W20	(B-4-19) 29aad	875 (267)	-	49 (15)	1976	836 (255)	4
W21	(B-4-19) 29dab	905 (276)	-	74 (22)	1973	831 (253)	2
W22	(B-3-18) 3bbb	1474 (449)	300 (91)	300 (91)	-	1174 (358)	2/Rock
W23	(B-3-18) 31cdd	1320 (402)	615 (187)	DRY	-	705 (215)	2
W24	(B-3-19) 9ccc	982 (299)	152 (46)	28 (8)	1978	954 (291)	4
W25	(B-3-19) 20cbb	1002 (305)	-	112 (34)	1973	890 (271)	2
W26	(B-3-19) 29aab	1037 (316)	184 (56)	143 (44)	1974	894 (272)	2
W27	(B-3-19) 29abb	1026 (313)	-	118 (36)	1974	908 (277)	2
W28	(B-3-19) 29bcc	1009 (307)	-	120 (37)	1968	889 (271)	2
W29	(B-3-20) 16dba	1400 (428)	265 (81)	119 (36)	1971	1281 (390)	2/In Rock
W30	(B-2-17) 19cab	1723 (525)	-	35 (11)	1973	1688 (514)	2
W31	(B-2-18) 9dcd	1490 (454)	177 (54)	120 (37)	1973	1370 (418)	2
W32	(B-2-18) 9ddd	1514 (461)	102 (31)	50 (15)	1968	1464 (446)	2
W33	(B-2-18) 11cac	1580 (481)	16 (5)	3 (1)	1968	1577 (481)	2
W34	(B-2-18) 14abb	1602 (494)	11 (3)	8 (2)	1968	1594 (486)	2

*Gila and Salt River Baseline and Meridian

**References

1) Metzger et. al. (1973)
2) U.S. Geological Survey (1975)
3) U.S. Geological Survey (1978a)
4) U.S. Geological Survey (1978b)
5) U.S. Geological Survey (1979)

NOTE: All wells tap unconfined alluvial aquifers except where noted. Where published data are lacking or inaccurate, ground surface elevations are taken from topographic maps.

GROUND WATER DATA
VERIFICATION SITE, LA POSA CDP,
ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 2-1

FUGRO NATIONAL, INC.

WELL NO.	WELL LOCATION NUMBER*	ELEVATION OF GROUND SURFACE-FEET (METERS) ABOVE M.S.L.	DEPTH OF WELL-FEET (METERS)	WATER LEVEL: DEPTH BELOW GROUND SURFACE-FEET (METERS)	WATER LEVEL: DATE MEASURED	WATER LEVEL: ELEVATION-FEET (METERS) ABOVE M.S.L.	REFERENCES**/ REMARKS
W35	(B-2-18) 16aaa	1514 (461)	-	48 (15)	1968	1466 (447)	2
W36	(B-2-18) 24add	1702 (519)	-	33 (10)	1973	1669 (509)	2
W37	(B-2-19) 31cda	1140 (347)	844 (257)	DRY	-	1096 (334)	5/Log

*Gila and Salt River Baseline and Meridian

**References

1) Metzger et. al. (1973)
2) U.S. Geological Survey (1975)
3) U.S. Geological Survey (1978a)
4) U.S. Geological Survey (1978b)
5) U.S. Geological Survey (1979)

NOTE: All wells tap unconfined alluvial aquifers except where noted. Where published data are lacking or inaccurate, ground surface elevations are taken from topographic maps.

GROUND WATER DATA
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 2-1
3 of 3

FUGRO NATIONAL, INC.

SECTION 3.0

SEISMIC REFRACTION DATA

EXPLANATIONS OF SEISMIC REFRACTION DATA

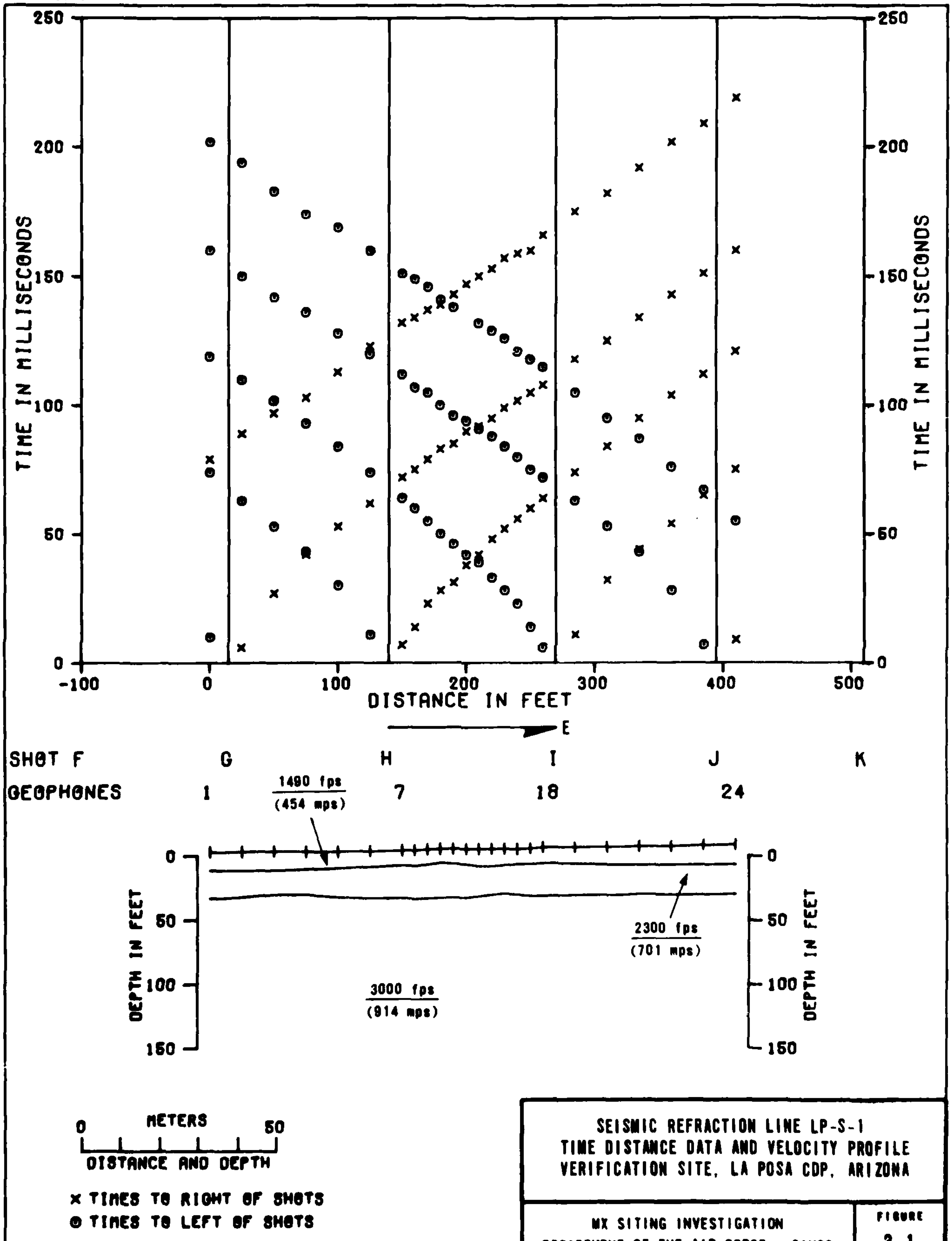
Each figure shows seismic wave travel times plotted versus surface distance between the energy source (shot) and the detector (geophone) for a single seismic line. Distances are measured along the line from geophone number 1 which is designated as zero distance. Distances to the right (on the paper) of geophone 1 are positive. The direction arrow gives the approximate direction of the geophone array from geophone 1 to geophone 24.

Travel Time Versus Distance Graph (Upper Half of Figure)

This is a travel time versus distance graph. The abscissa represents distance; the ordinate, time. The six vertical lines represent the locations of shots (designated as F, G, H, I, J, and K). The symbol, X, denotes travel times at geophones that were located to the right of a shot. The symbol, ⊙, denotes travel times that were located to the left of shots.

Velocity Cross Section (Lower Half of Figure)

This is an interpreted velocity cross section beneath the seismic line. The top line represents the ground-surface profile. The short vertical lines crossing the top line mark the geophone positions. The depth scale is plotted relative to a point on the line which was arbitrarily chosen as "zero elevation" at the time the line was surveyed. The additional lines across the cross section represent the interpreted boundaries between layers of material with different compressional wave velocities. These boundaries are commonly called "refractors". The velocity interpreted to be representative of each layer is shown.



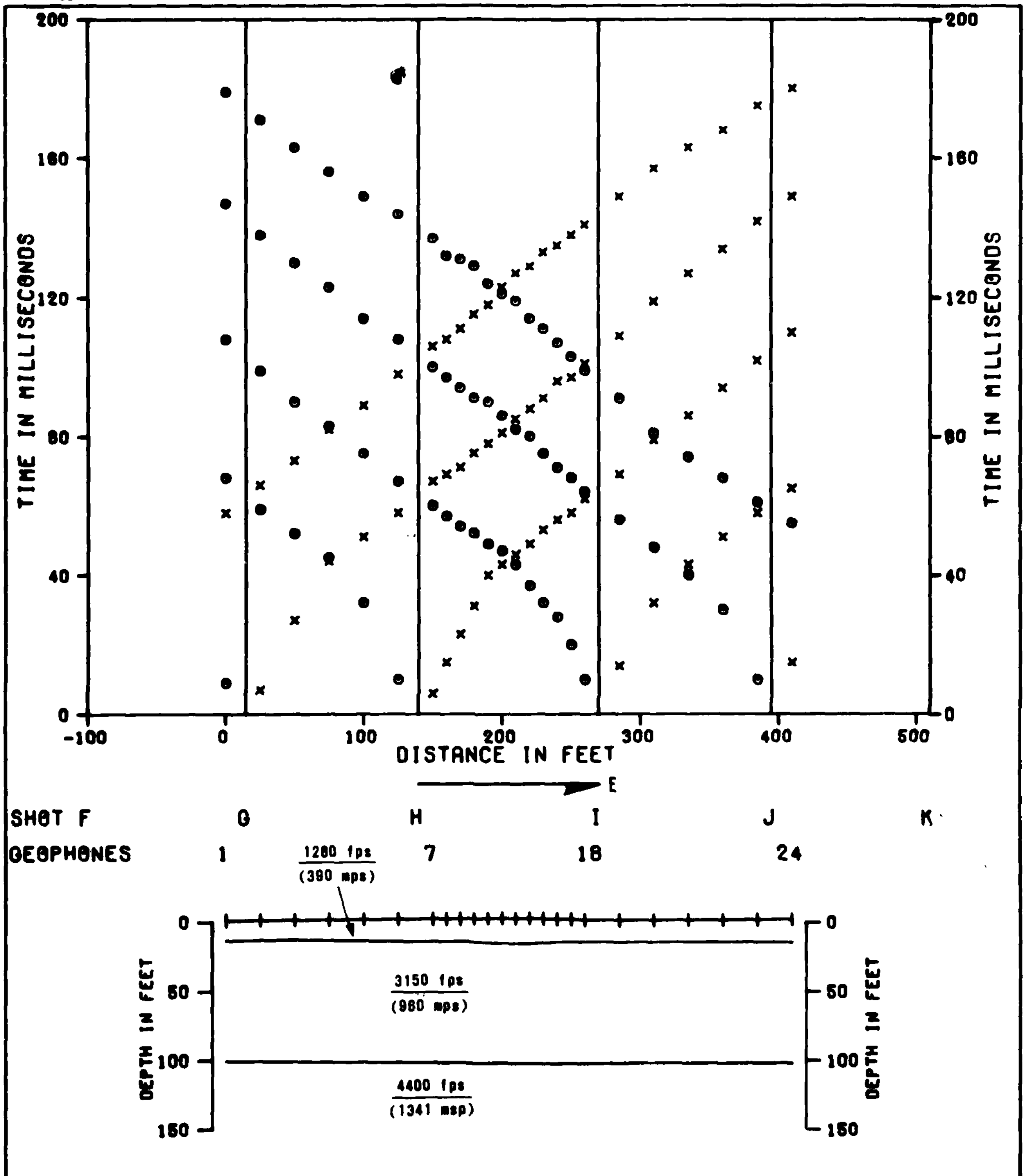
SEISMIC REFRACTION LINE LP-S-1
TIME DISTANCE DATA AND VELOCITY PROFILE
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 3-1

FUGRO NATIONAL, INC.

10 AUG 79



0 METERS 50

DISTANCE AND DEPTH

× TIMES TO RIGHT OF SHOTS

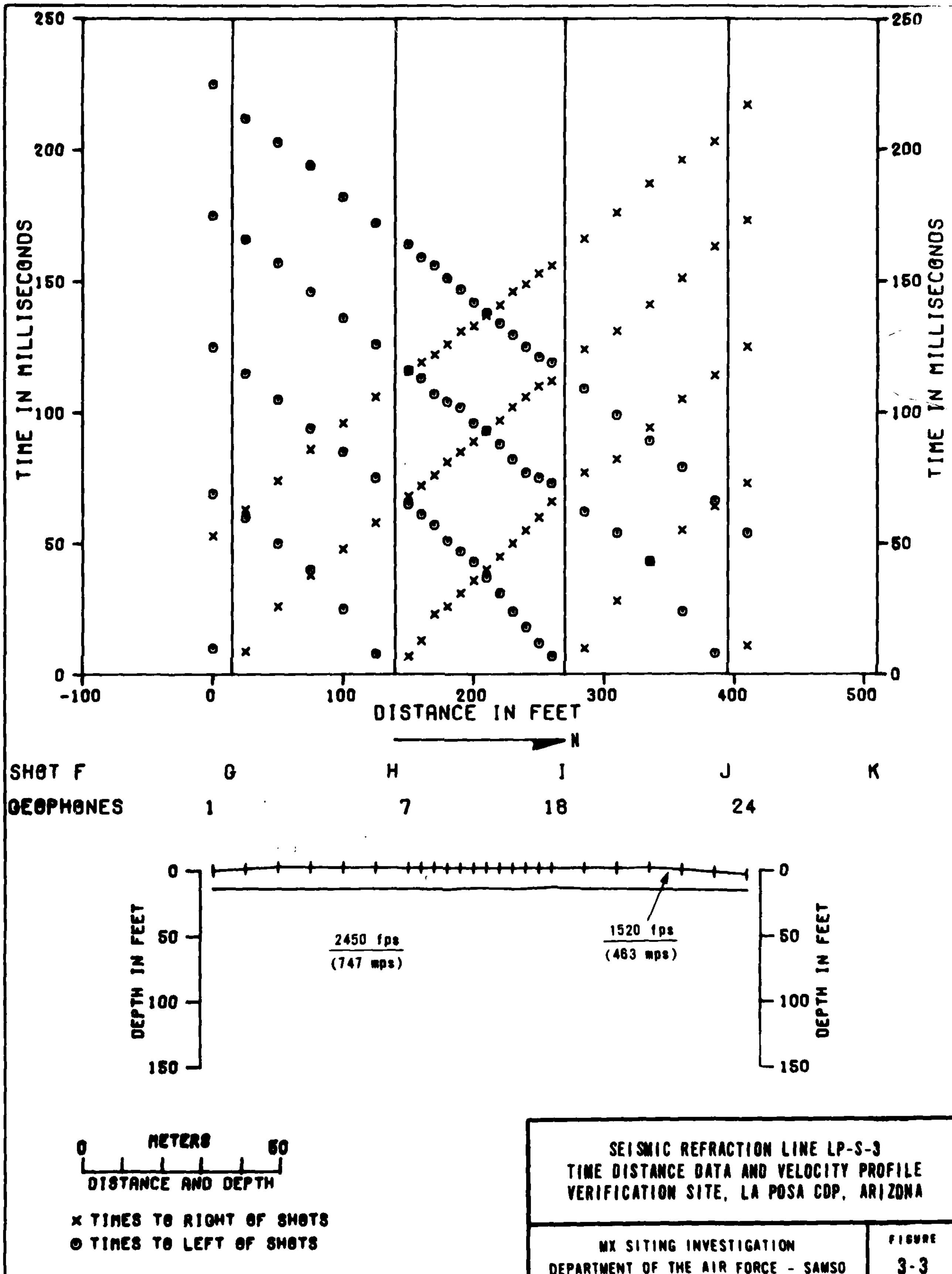
⊙ TIMES TO LEFT OF SHOTS

SEISMIC REFRACTION LINE LP-S-2
TIME DISTANCE DATA AND VELOCITY PROFILE
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	FIGURE 3-2

FUGRO NATIONAL, INC.

10 AUG 79



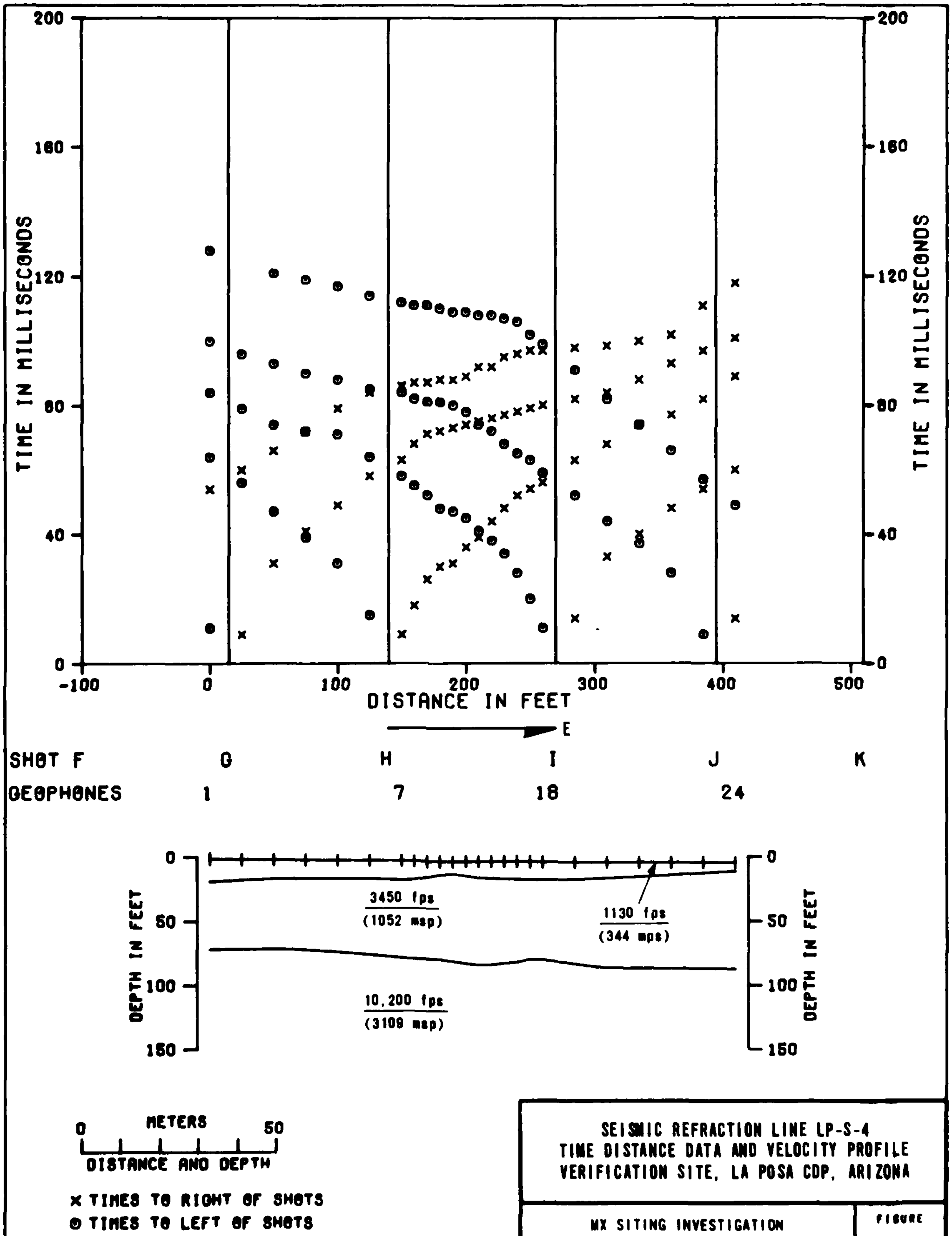
SEISMIC REFRACTION LINE LP-S-3
TIME DISTANCE DATA AND VELOCITY PROFILE
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 3-3

FUGRO NATIONAL, INC.

10 AUG 79

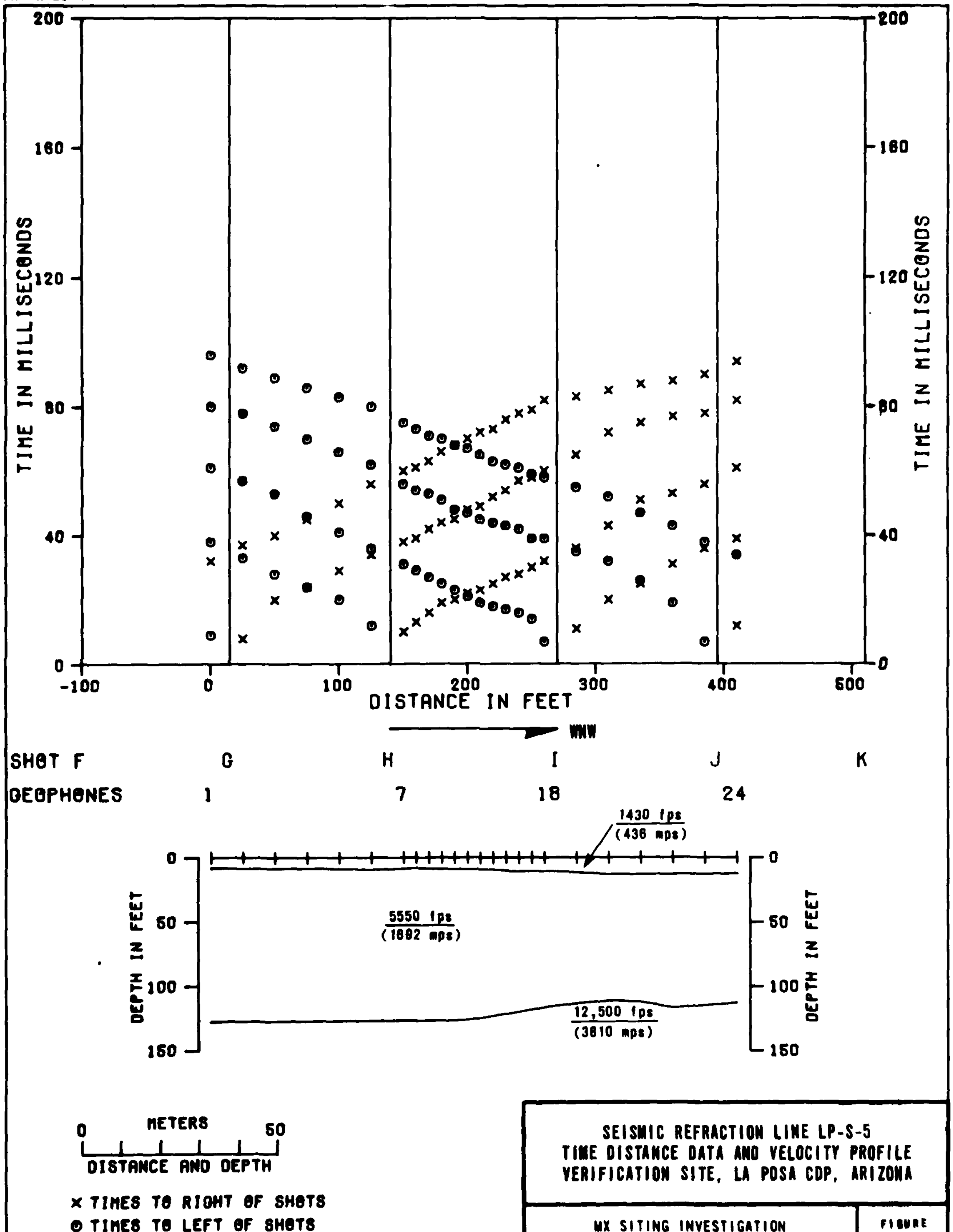


SEISMIC REFRACTION LINE LP-S-4
TIME DISTANCE DATA AND VELOCITY PROFILE
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	FIGURE 3-4

FUGRO NATIONAL, INC.

10 AUG 79

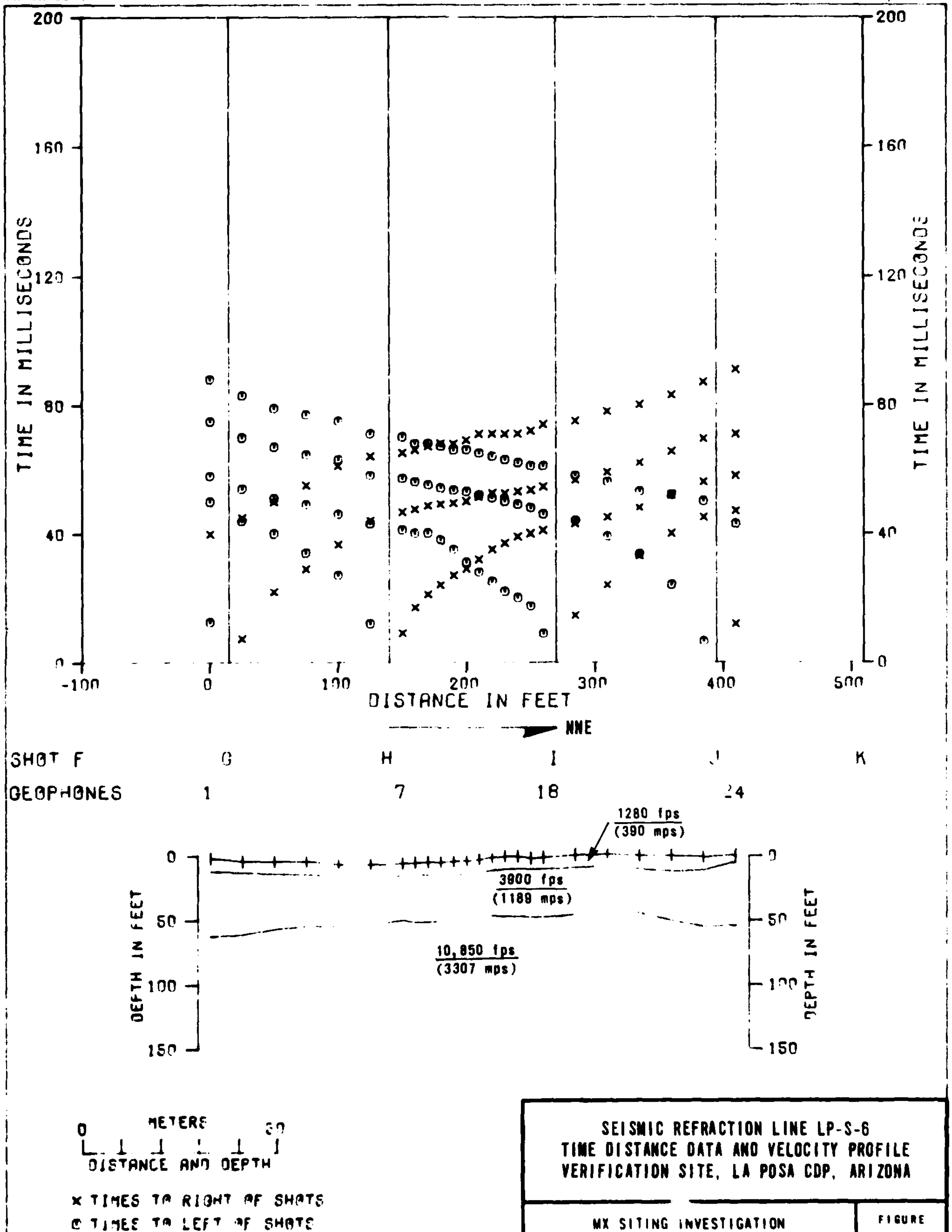


SEISMIC REFRACTION LINE LP-S-5
TIME DISTANCE DATA AND VELOCITY PROFILE
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	FIGURE 3-5

FUGRO NATIONAL, INC.

10 AUG 79

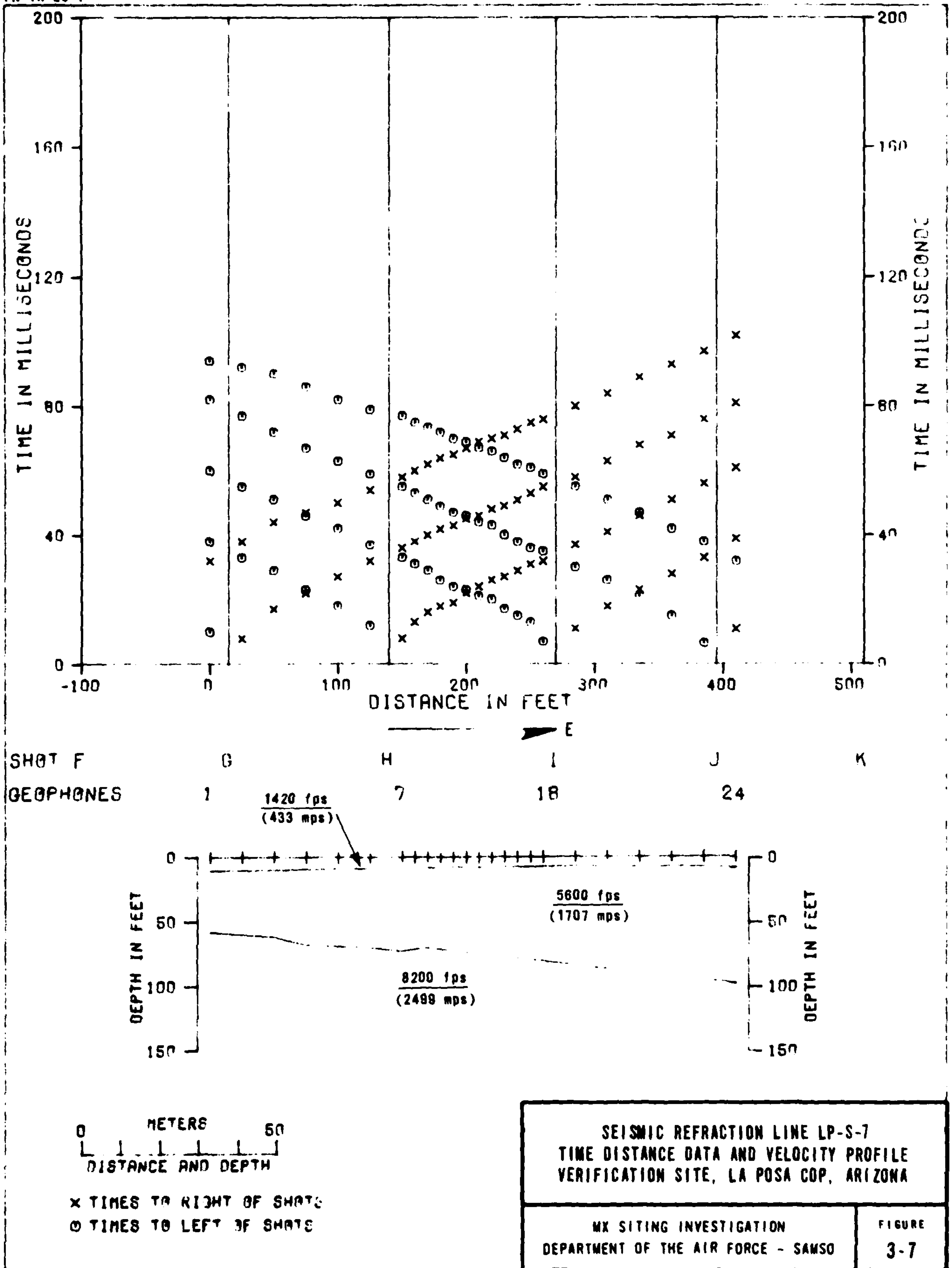


SEISMIC REFRACTION LINE LP-S-6
TIME DISTANCE DATA AND VELOCITY PROFILE
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 3-6

FUGRO NATIONAL, INC.



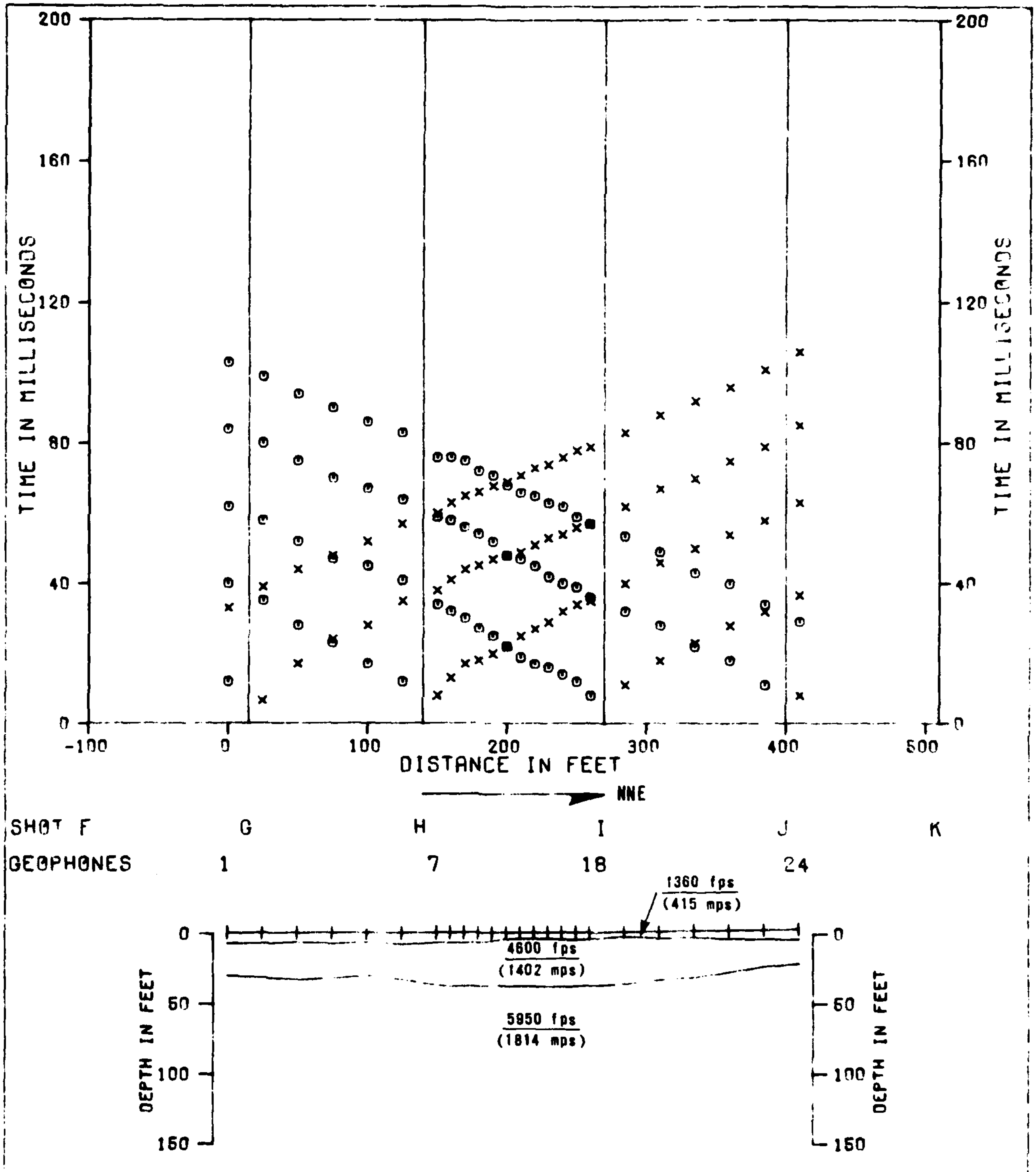
SEISMIC REFRACTION LINE LP-S-7
TIME DISTANCE DATA AND VELOCITY PROFILE
VERIFICATION SITE, LA POSA COP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 3-7

FUGRO NATIONAL, INC.

10 AUG 79



0 METERS 50
DISTANCE AND DEPTH

× TIMES TO RIGHT OF SHOTS
⊙ TIMES TO LEFT OF SHOTS

SEISMIC REFRACTION LINE LP-S-8
TIME DISTANCE DATA AND VELOCITY PROFILE
VERIFICATION SITE, LA POSA CDP, ARIZONA

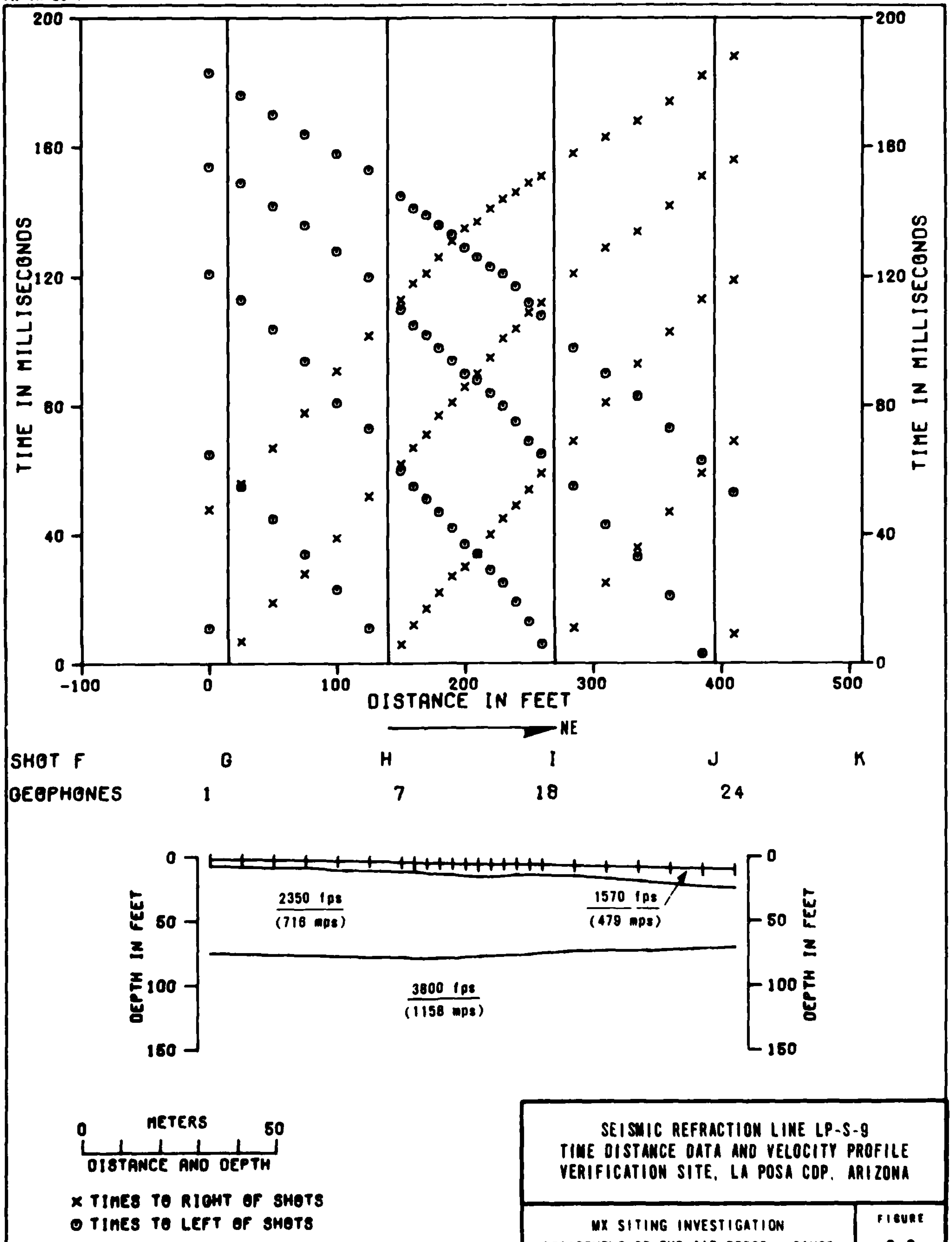
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 3-8

FUGRO NATIONAL, INC.

10 AUG 79

FN-TR-28-I



SEISMIC REFRACTION LINE LP-S-9
TIME DISTANCE DATA AND VELOCITY PROFILE
VERIFICATION SITE, LA POSA CDP, ARIZONA

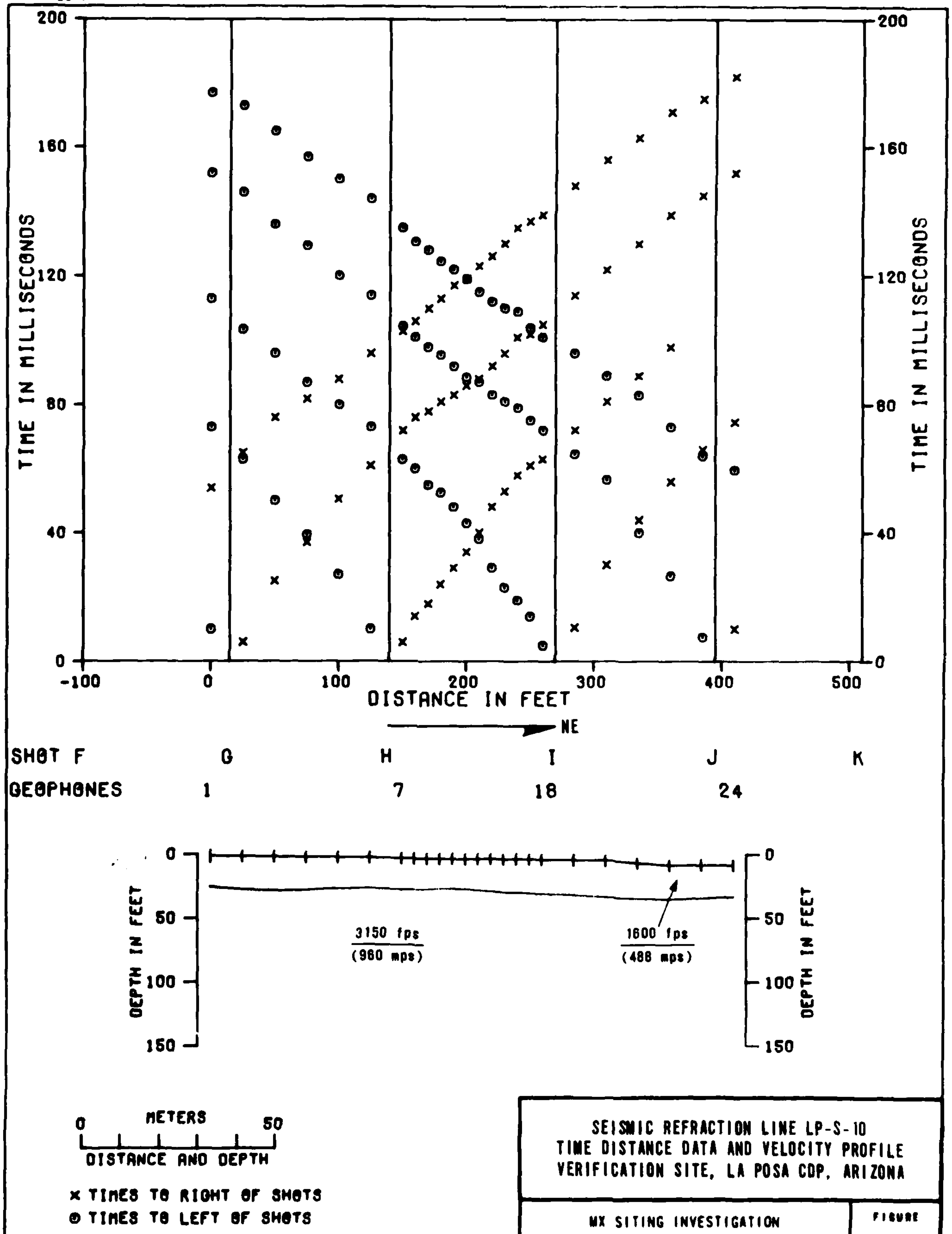
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 3-9

FUGRO NATIONAL, INC.

10 AUG 79

FN TR-28-1



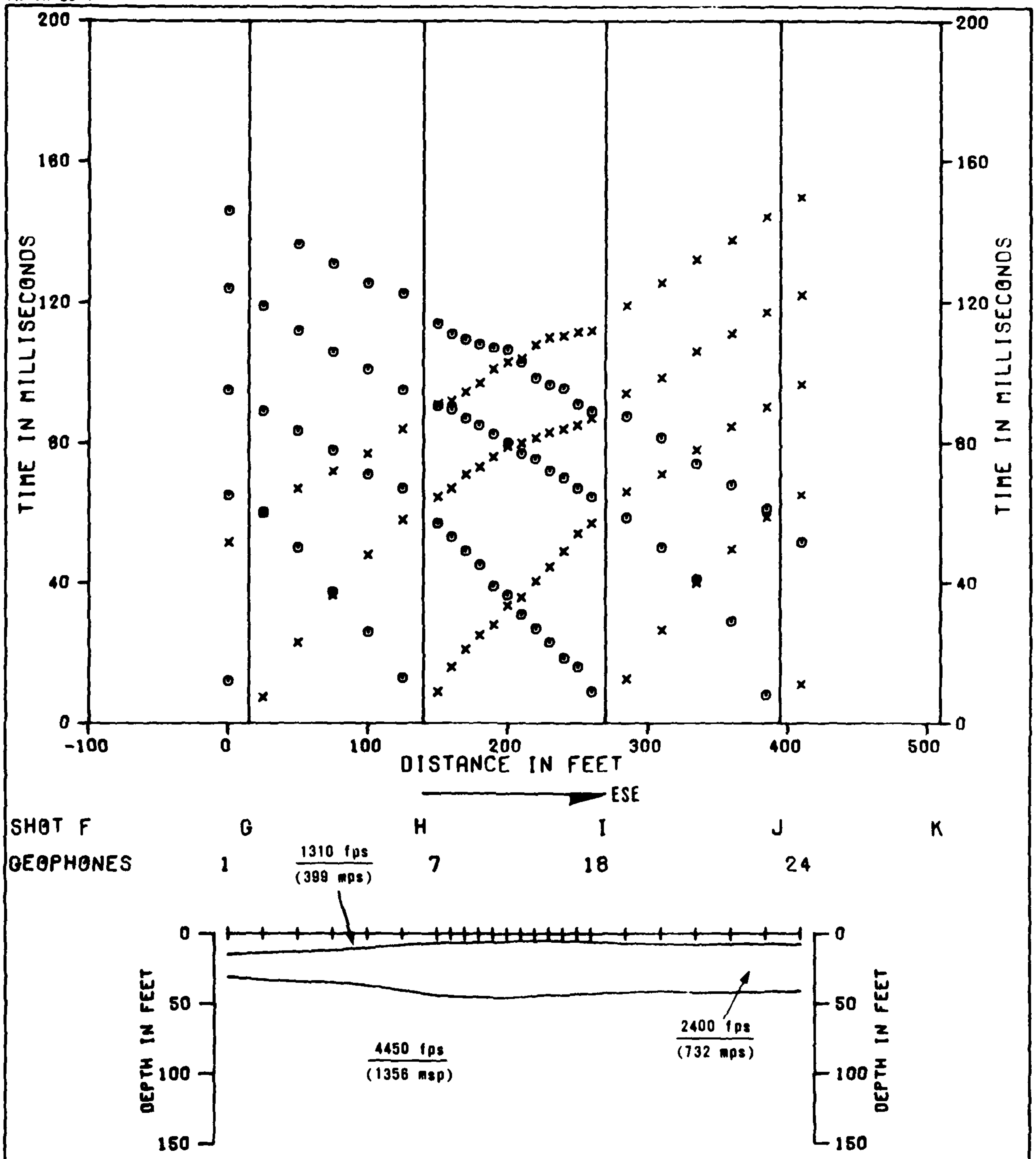
SEISMIC REFRACTION LINE LP-S-10
TIME DISTANCE DATA AND VELOCITY PROFILE
VERIFICATION SITE, LA POSA CDP, ARIZONA

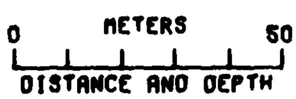
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 3-10

FUGRO NATIONAL, INC.

10 AUG 79





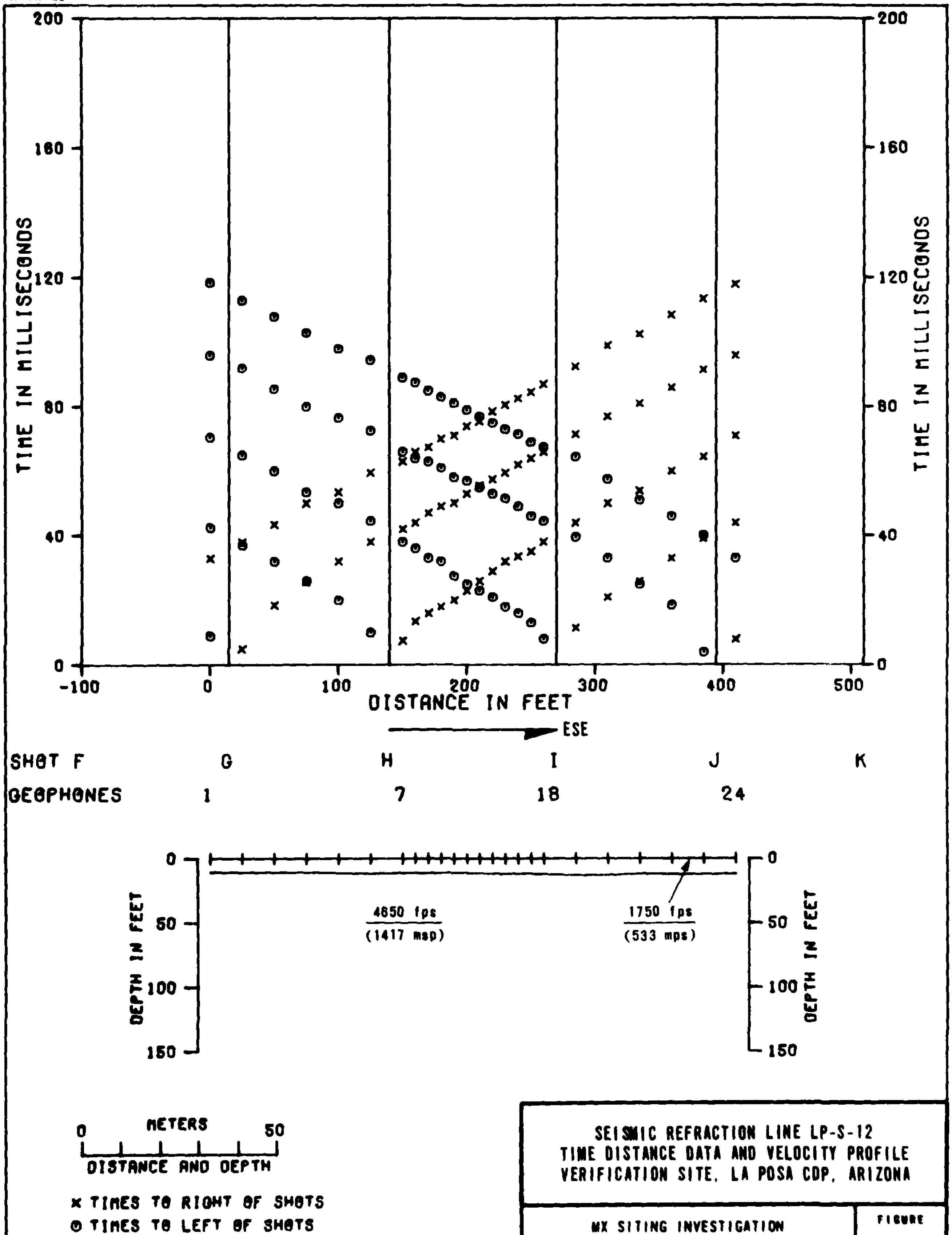
× TIMES TO RIGHT OF SHOTS
⊙ TIMES TO LEFT OF SHOTS

SEISMIC REFRACTION LINE LP-S-11
TIME DISTANCE DATA AND VELOCITY PROFILE
VERIFICATION SITE, LA POSA COP, ARIZONA

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	FIGURE 3-11

FUGRO NATIONAL, INC.

10 AUG 79



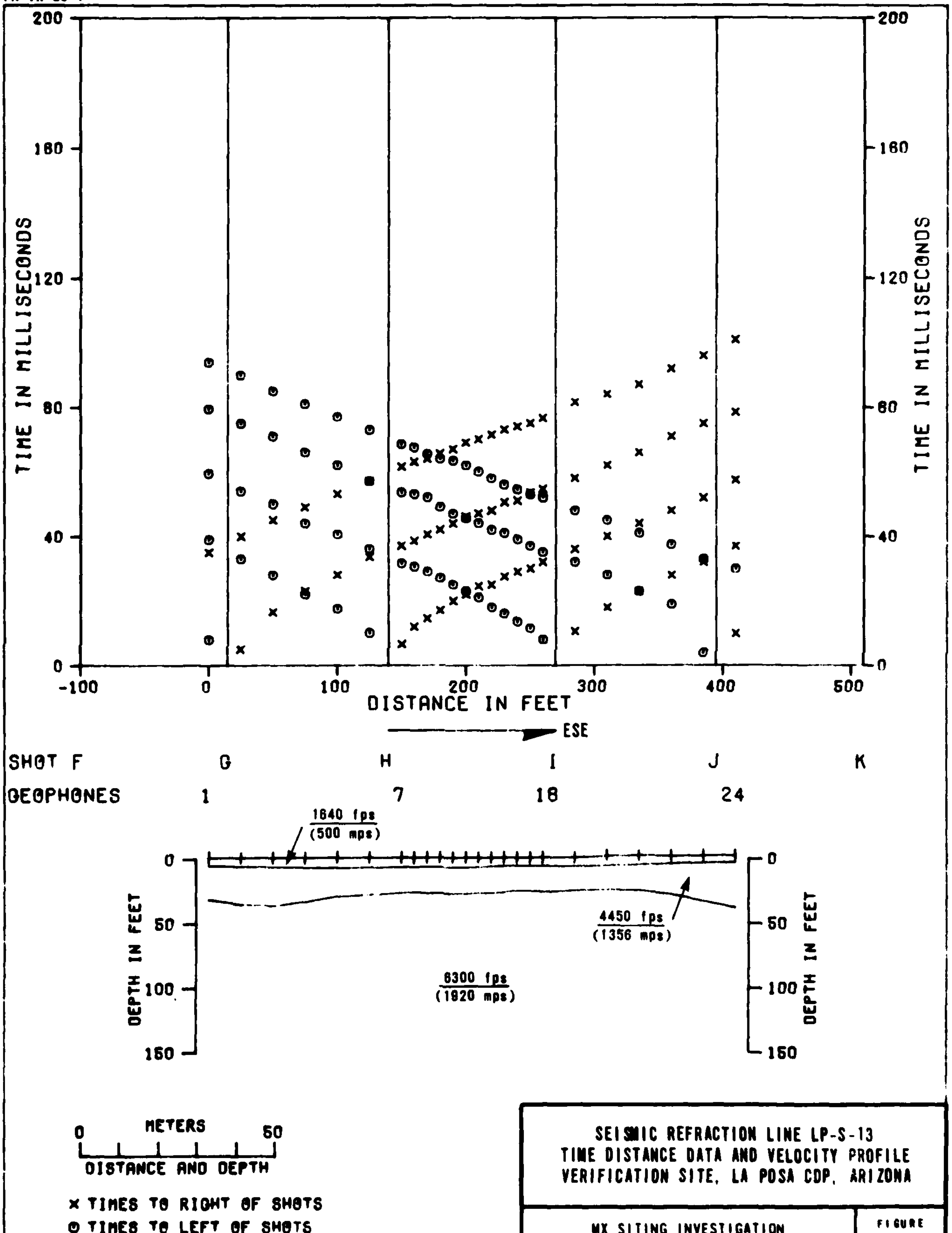
SEISMIC REFRACTION LINE LP-S-12
TIME DISTANCE DATA AND VELOCITY PROFILE
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 3-12

FUGRO NATIONAL, INC.

10 AUG 79



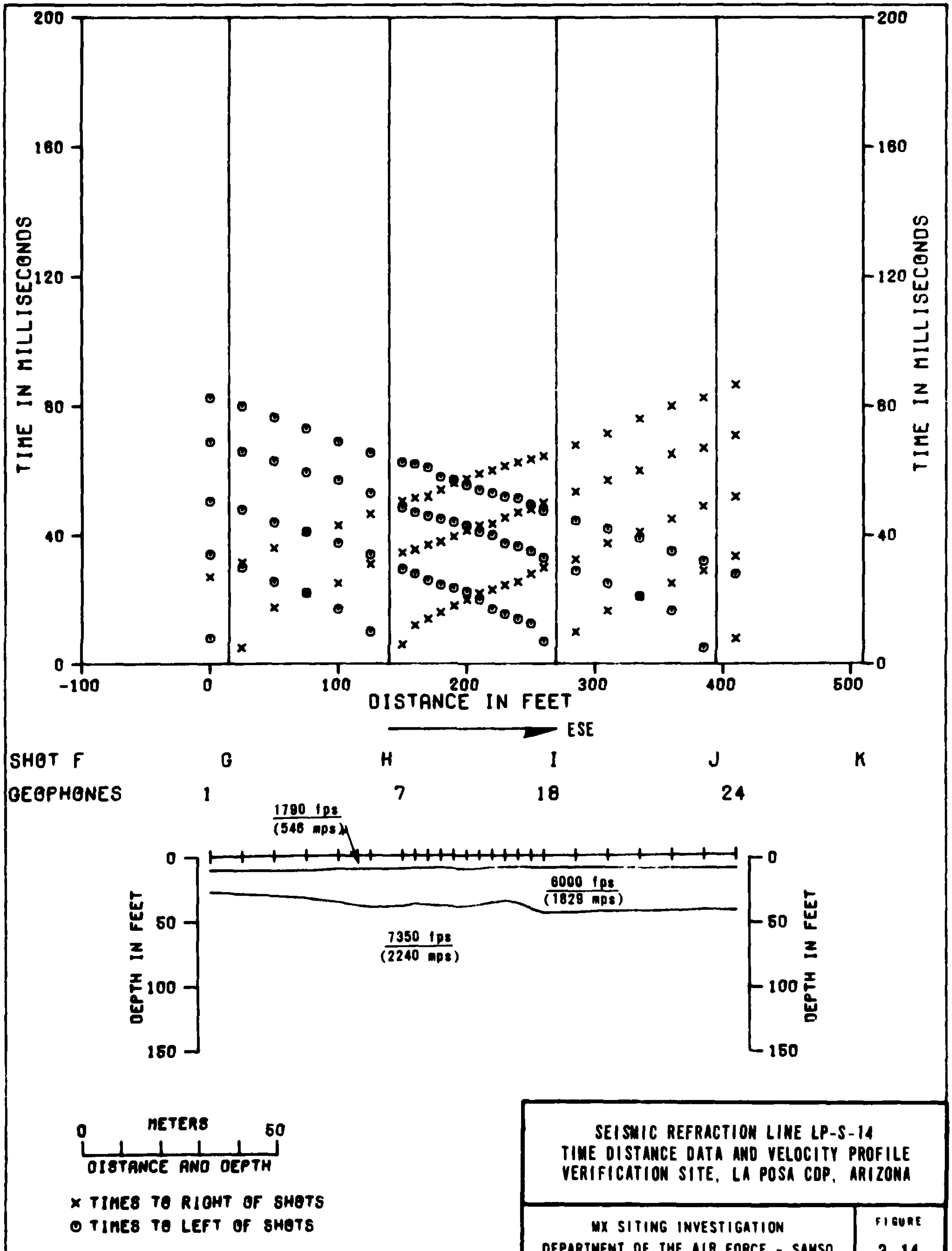
SEISMIC REFRACTION LINE LP-S-13
TIME DISTANCE DATA AND VELOCITY PROFILE
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 3-13

FUGRO NATIONAL, INC.

10 AUG 79



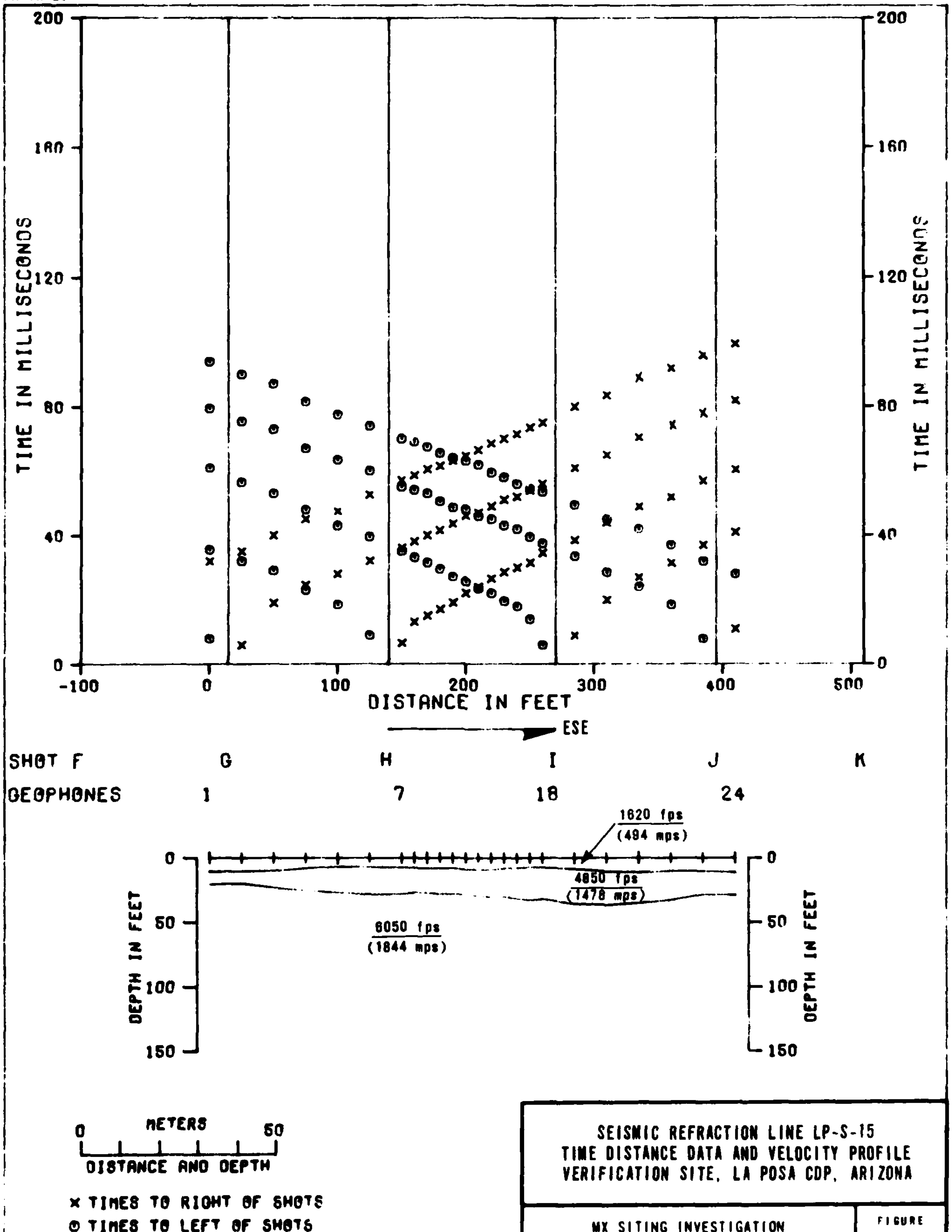
SEISMIC REFRACTION LINE LP-S-14
TIME DISTANCE DATA AND VELOCITY PROFILE
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 3-14

FUGRO NATIONAL, INC.

10 AUG 79



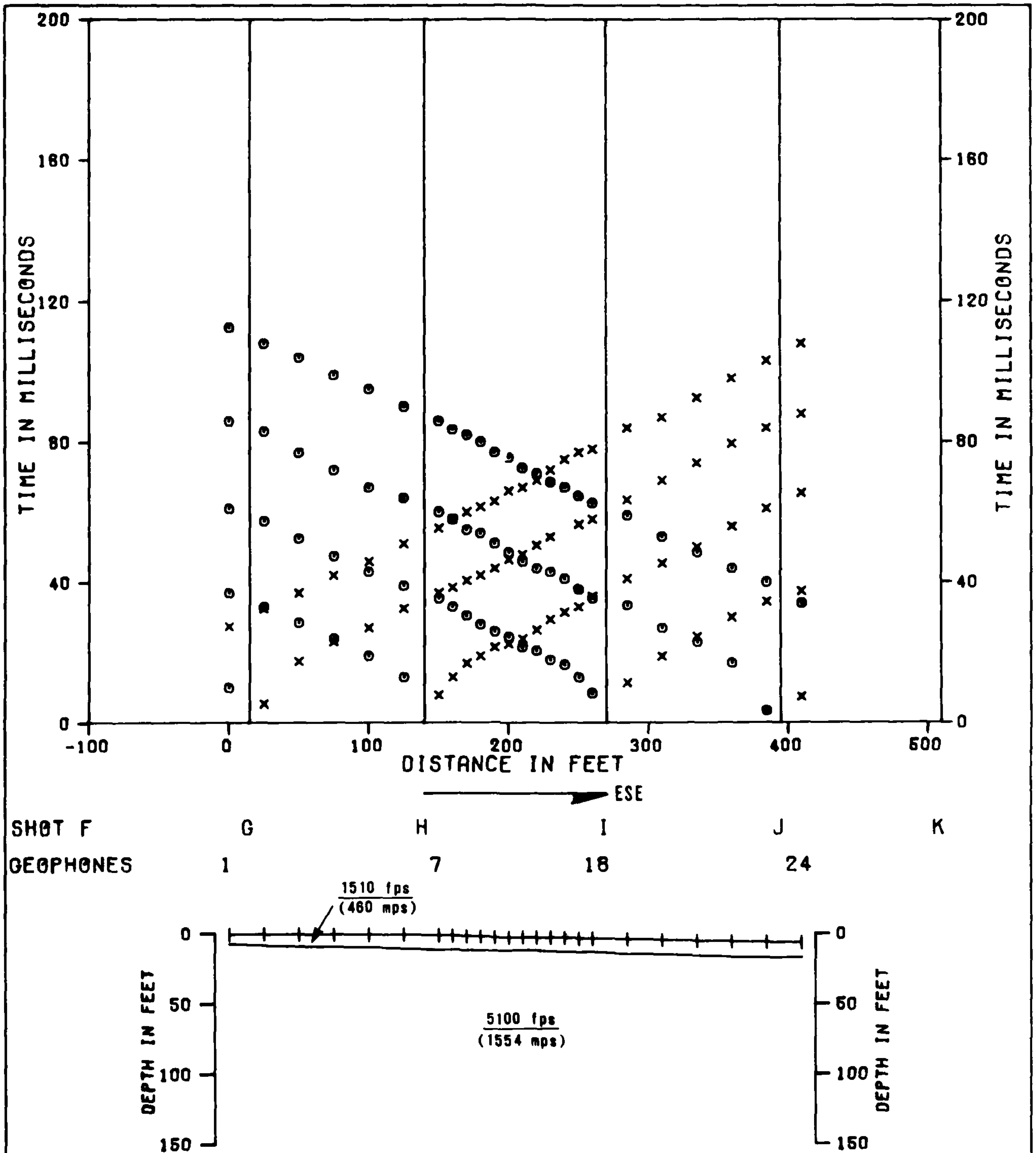
SEISMIC REFRACTION LINE LP-S-15
TIME DISTANCE DATA AND VELOCITY PROFILE
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 3-15

FUGRO NATIONAL, INC.

10 AUG 79



0 METERS 50

DISTANCE AND DEPTH

× TIMES TO RIGHT OF SHOTS

⊙ TIMES TO LEFT OF SHOTS

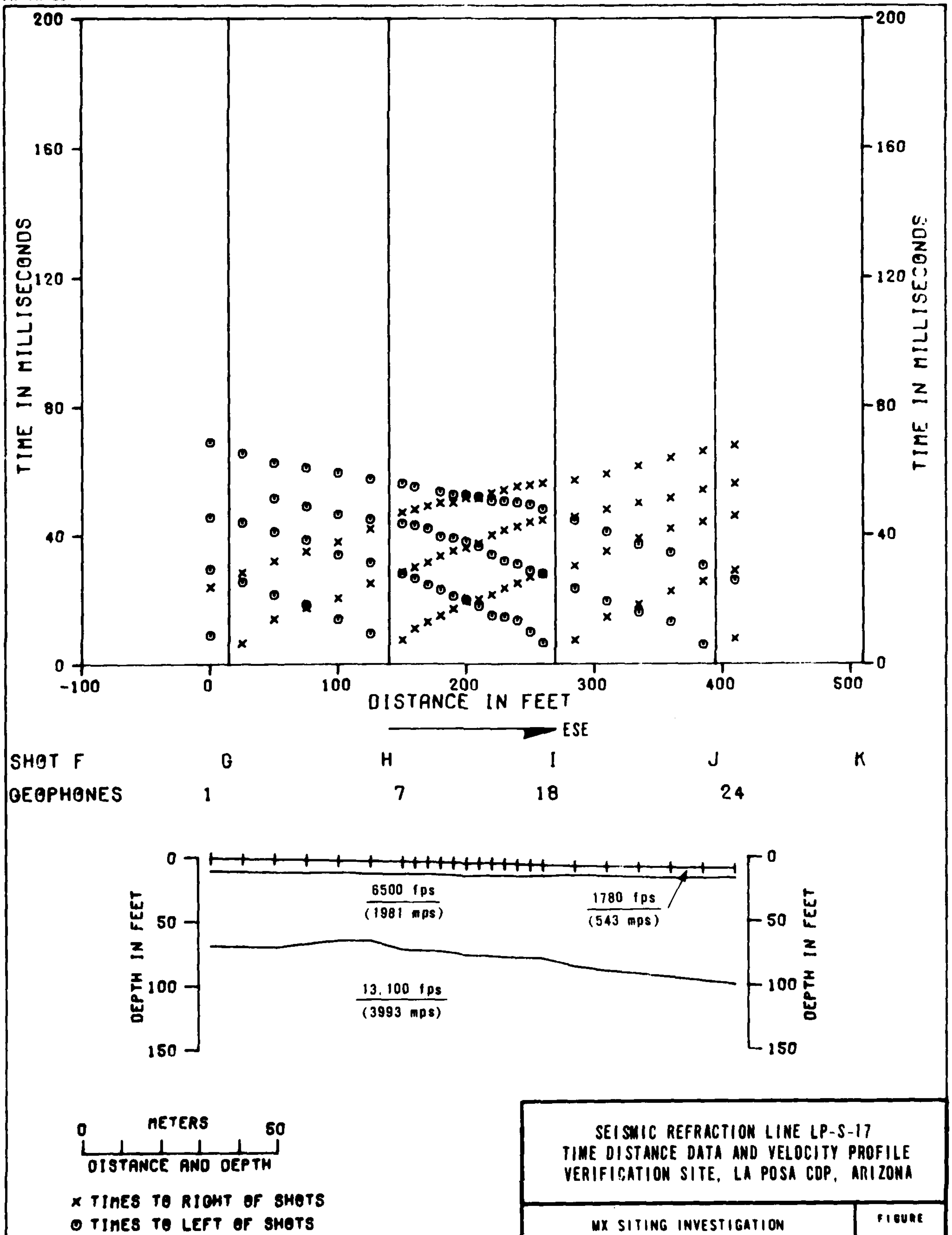
SEISMIC REFRACTION LINE LP-S-16
TIME DISTANCE DATA AND VELOCITY PROFILE
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 3-16

FUGRO NATIONAL, INC.

10 AUG 79



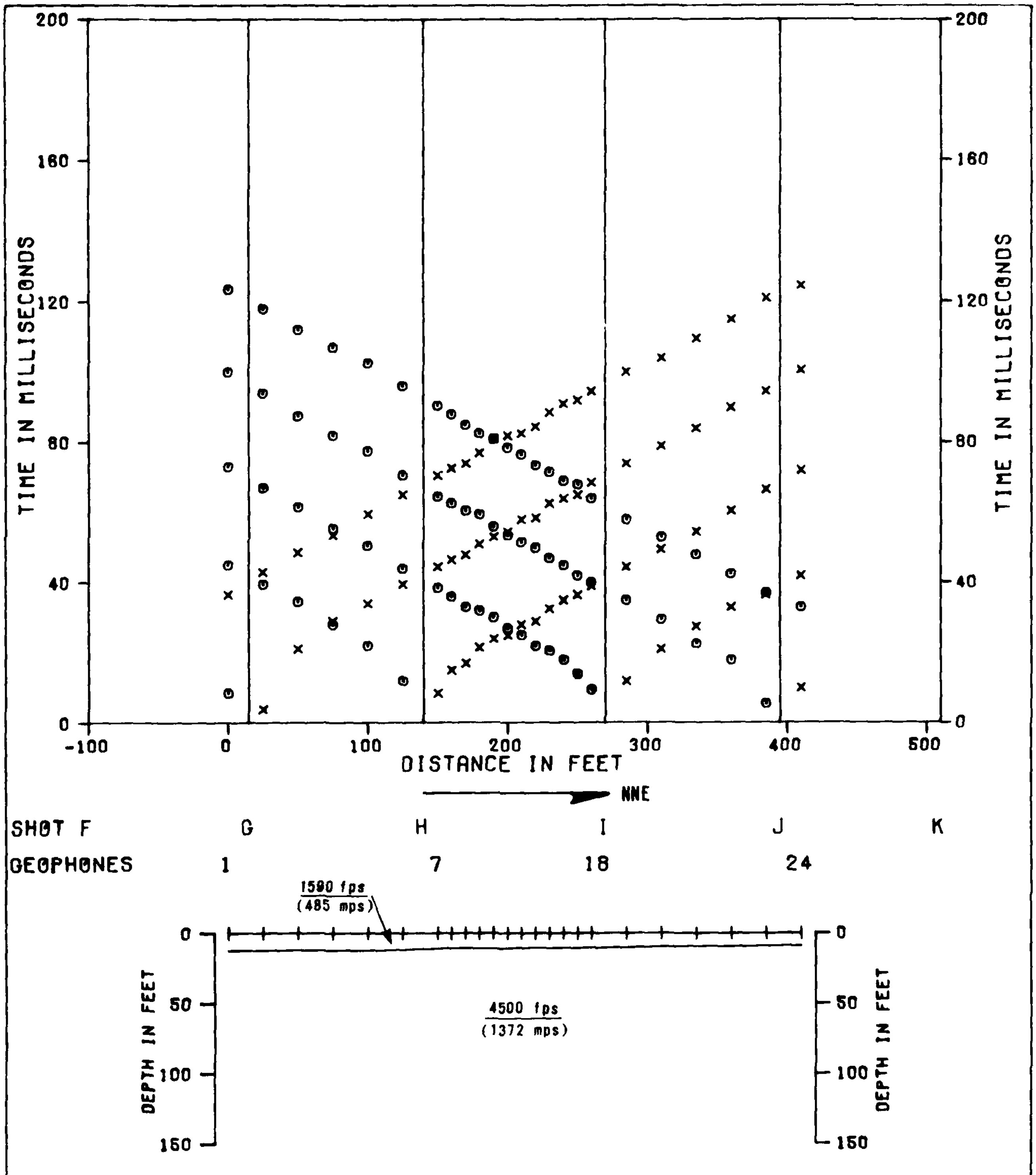
SEISMIC REFRACTION LINE LP-S-17
TIME DISTANCE DATA AND VELOCITY PROFILE
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 3-17

FUGRO NATIONAL, INC.

10 AUG 79



0 METERS 50
DISTANCE AND DEPTH

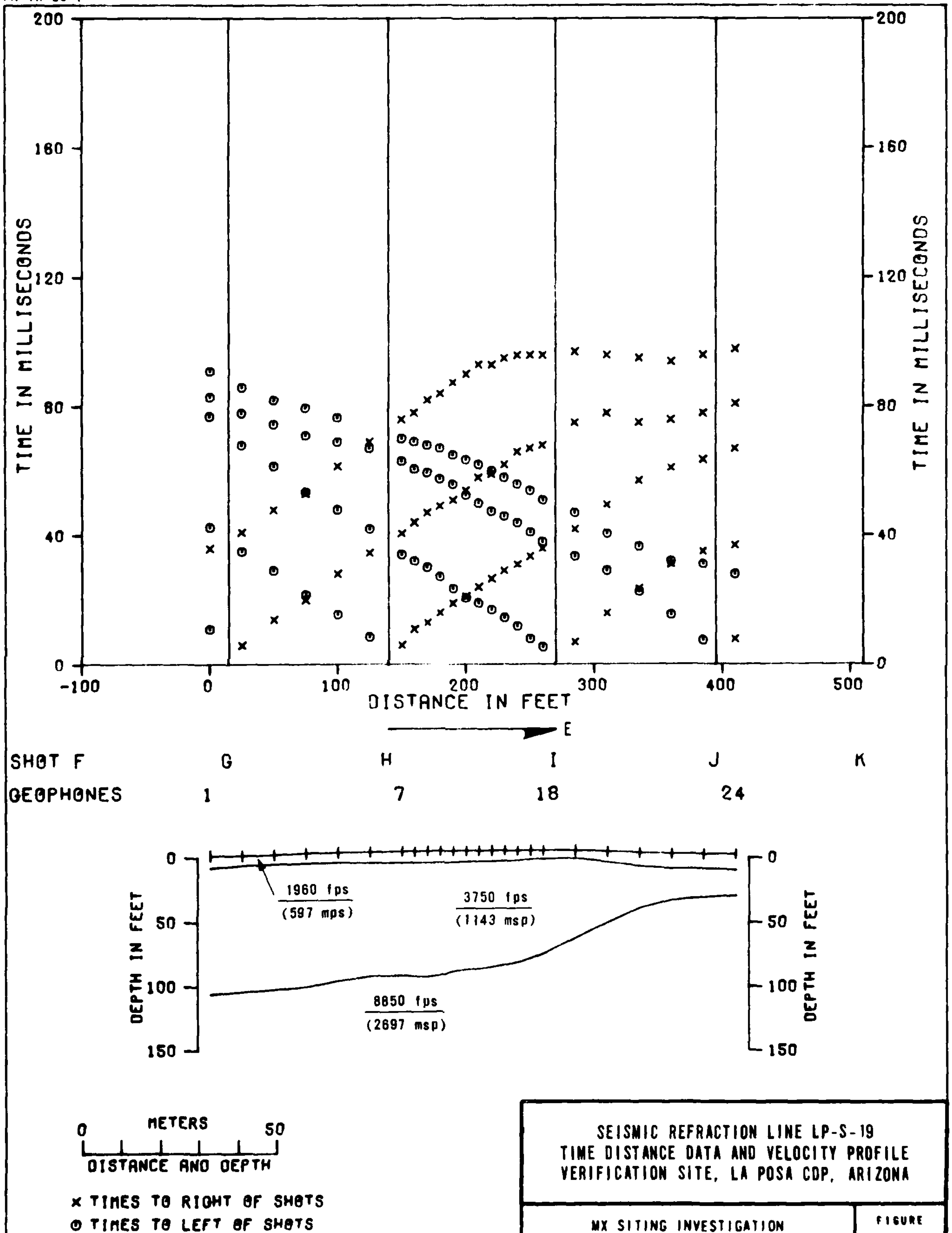
× TIMES TO RIGHT OF SHOTS
⊙ TIMES TO LEFT OF SHOTS

SEISMIC REFRACTION LINE LP-S-18
TIME DISTANCE DATA AND VELOCITY PROFILE
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 3-18

FUGRO NATIONAL, INC.



SEISMIC REFRACTION LINE LP-S-19
TIME DISTANCE DATA AND VELOCITY PROFILE
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 3-19

FUGRO NATIONAL, INC.

10 AUG 79

SECTION 4.0

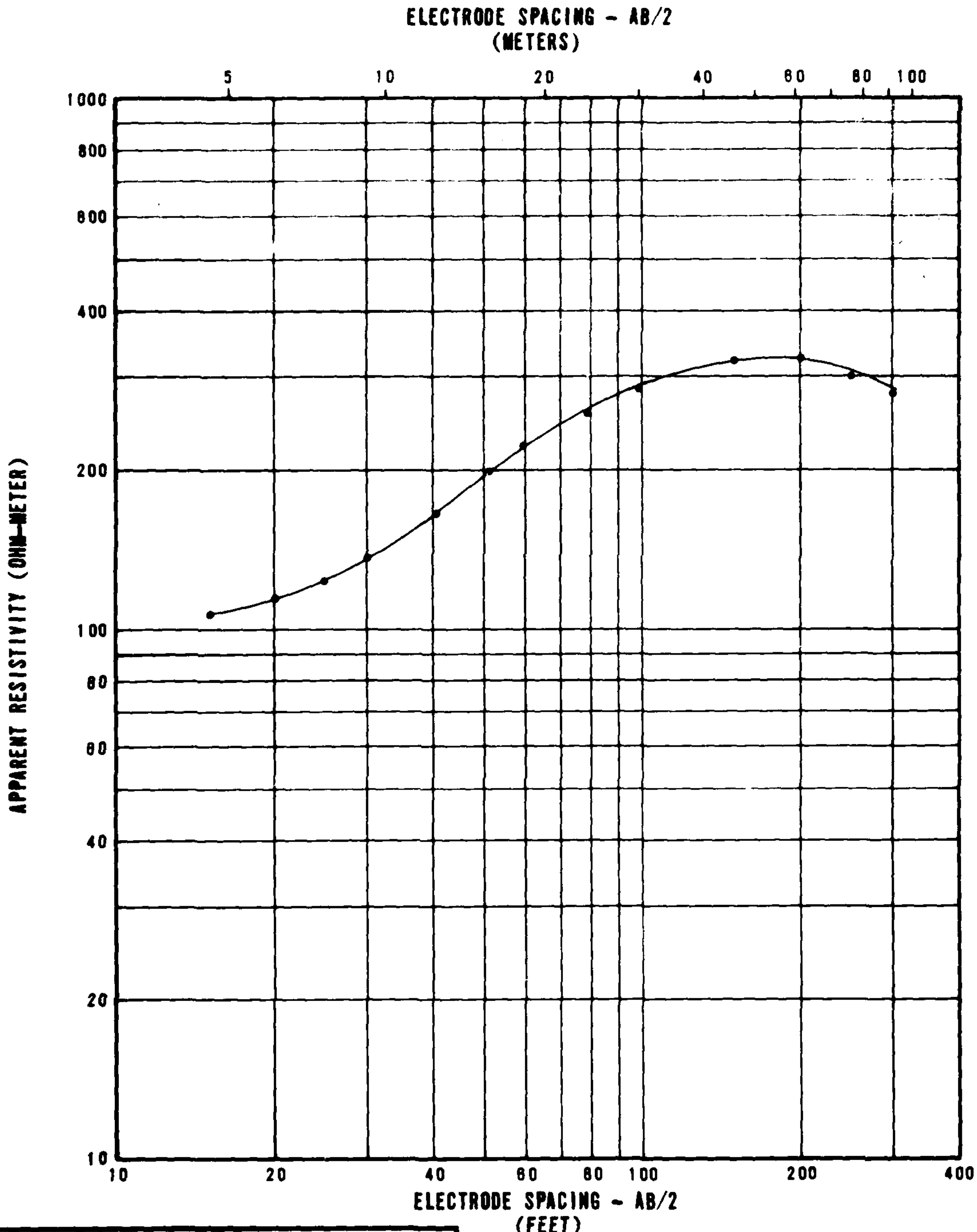
ELECTRICAL RESISTIVITY DATA

EXPLANATIONS OF ELECTRICAL RESISTIVITY DATA

Each figure in this section presents the data obtained from a resistivity sounding and a tabulated model of resistivity layers that would produce a curve similar to the observed curve.

The upper portion of the figures is a graph in which measured apparent resistivity values in ohm-meters are plotted versus one-half the distance between the current electrodes.

The interpreted model tabulated at the bottom of the page shows a combination of true resistivity layers and thicknesses obtained by matching theoretical curves to the field curve.



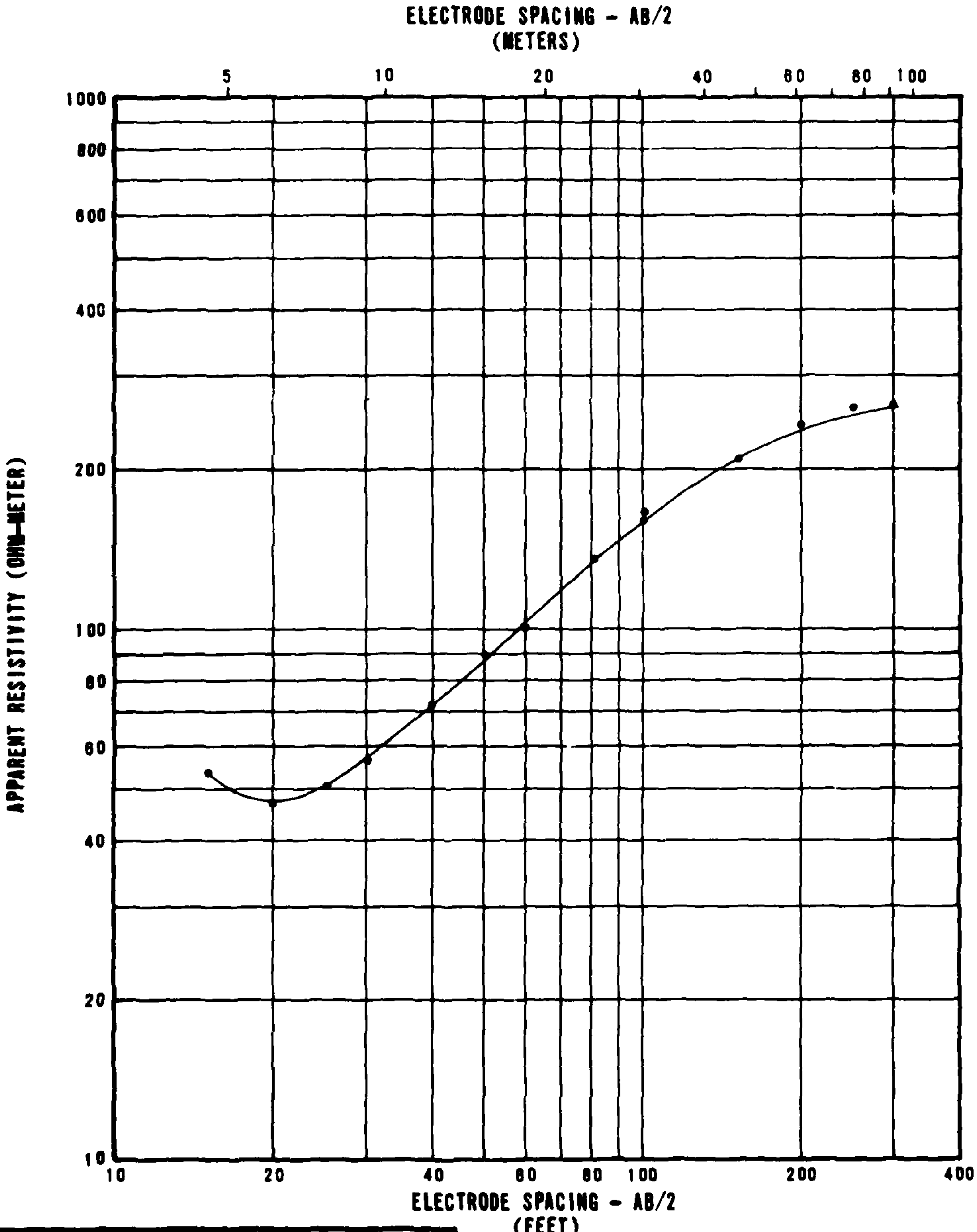
INTERPRETED MODEL		
LAYER DEPTH		RESISTIVITY VALUES
FEET	METERS	OHM-METER
0	0	100
17	5	470
149	45	120

RESISTIVITY SOUNDING LP-R-1
SOUNDING CURVE AND INTERPRETATION
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 4-1

FUGRO NATIONAL, INC.



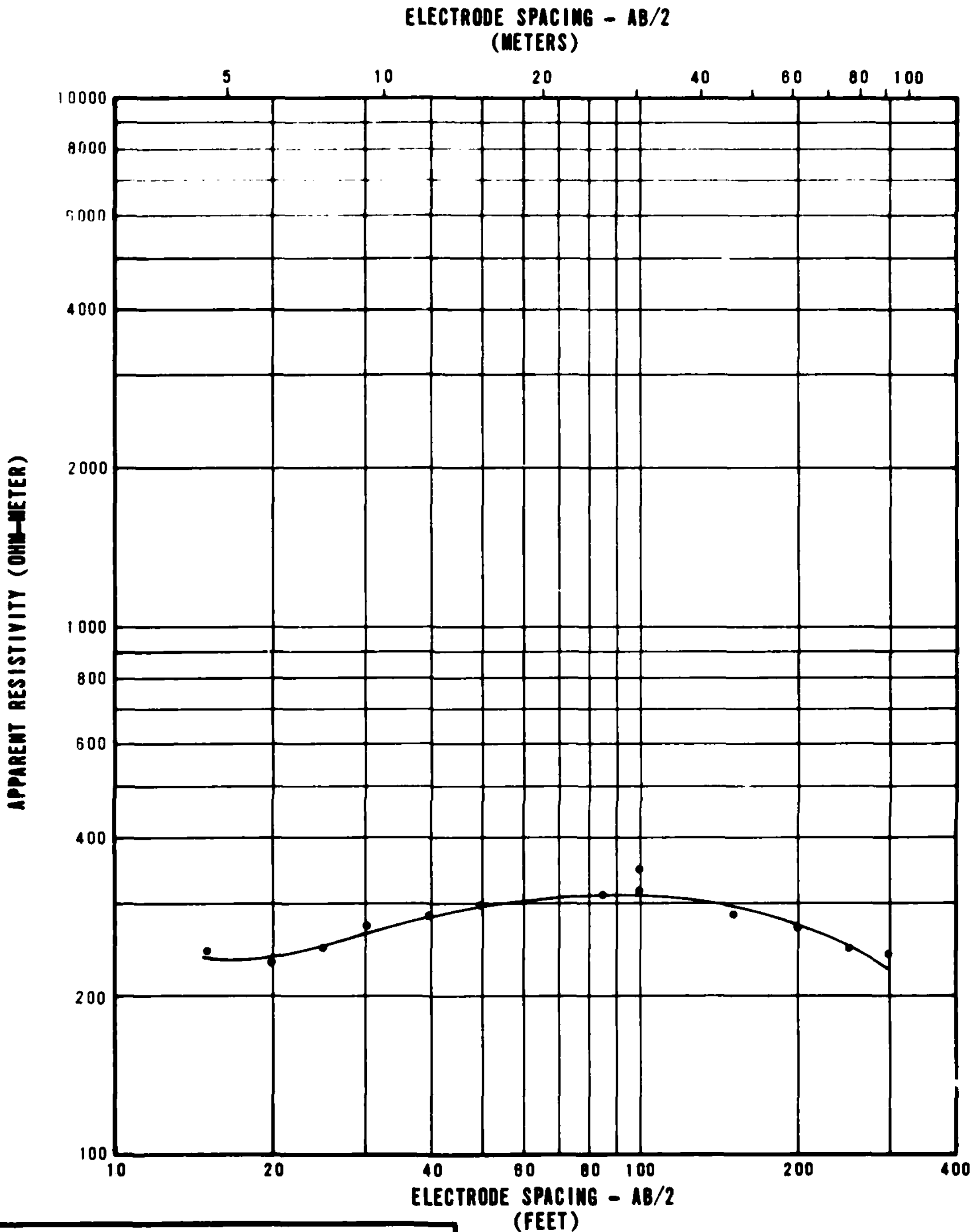
INTERPRETED MODEL		
LAYER DEPTH		RESISTIVITY VALUES
FEET	METERS	OHM-METER
0	0	80
4	1	45
24	7	600
102	31	260

RESISTIVITY SOUNDING LP-R-2
SOUNDING CURVE AND INTERPRETATION
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 4-2

FUGRO NATIONAL, INC.



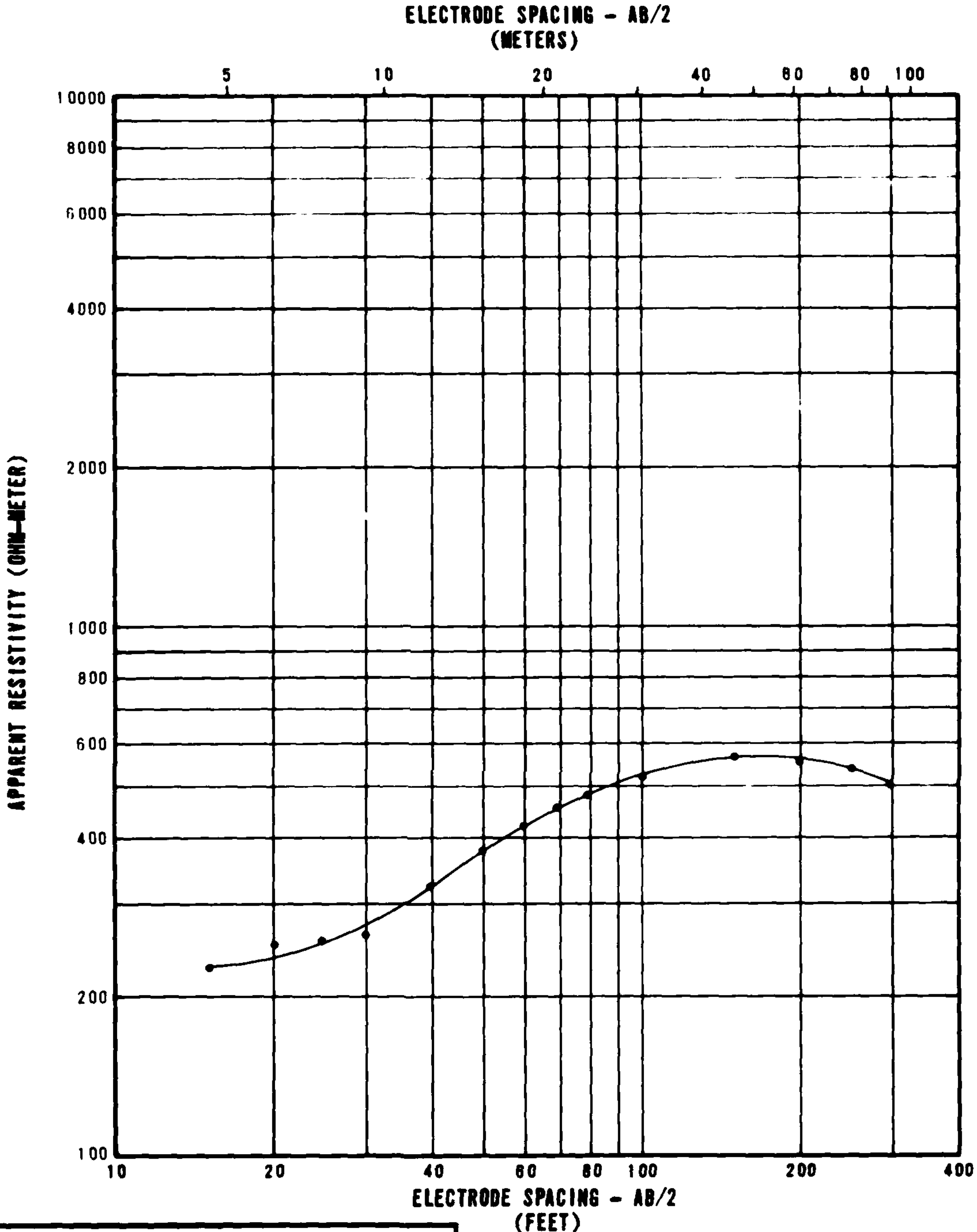
INTERPRETED MODEL		
LAYER DEPTH		RESISTIVITY VALUES
FEET	METERS	OHM-METER
0	0	230
21	6	410
75	23	200
183	56	130

RESISTIVITY SOUNDING LP-R-3
SOUNDING CURVE AND INTERPRETATION
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 4-3

FUGRO NATIONAL, INC.



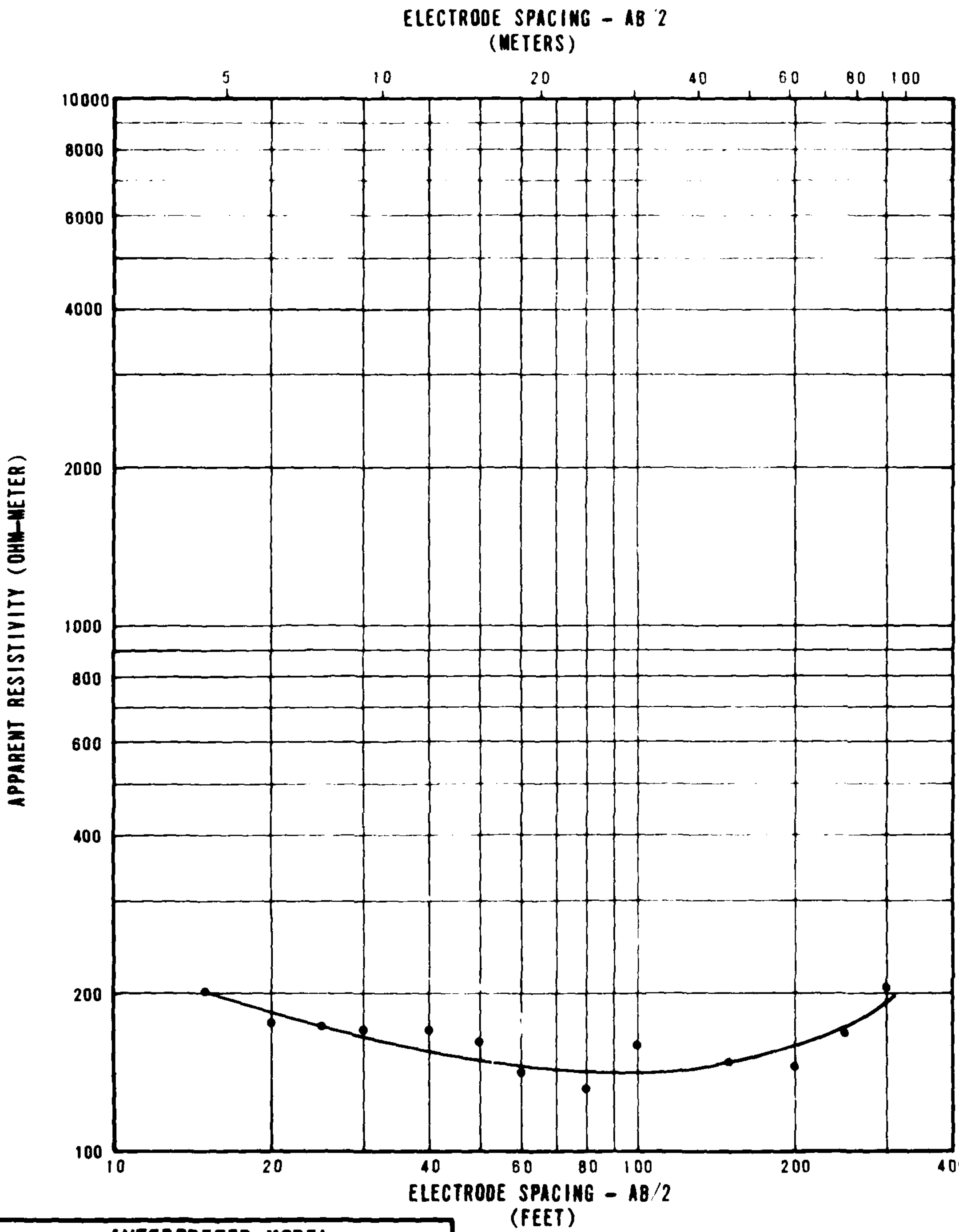
INTERPRETED MODEL		
LAYER DEPTH		RESISTIVITY VALUES
FEET	METERS	OHM-METER
0	0	220
17	5	690
150	46	260

RESISTIVITY SOUNDING LP-R-4
SOUNDING CURVE AND INTERPRETATION
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 4-4

FUGRO NATIONAL, INC.



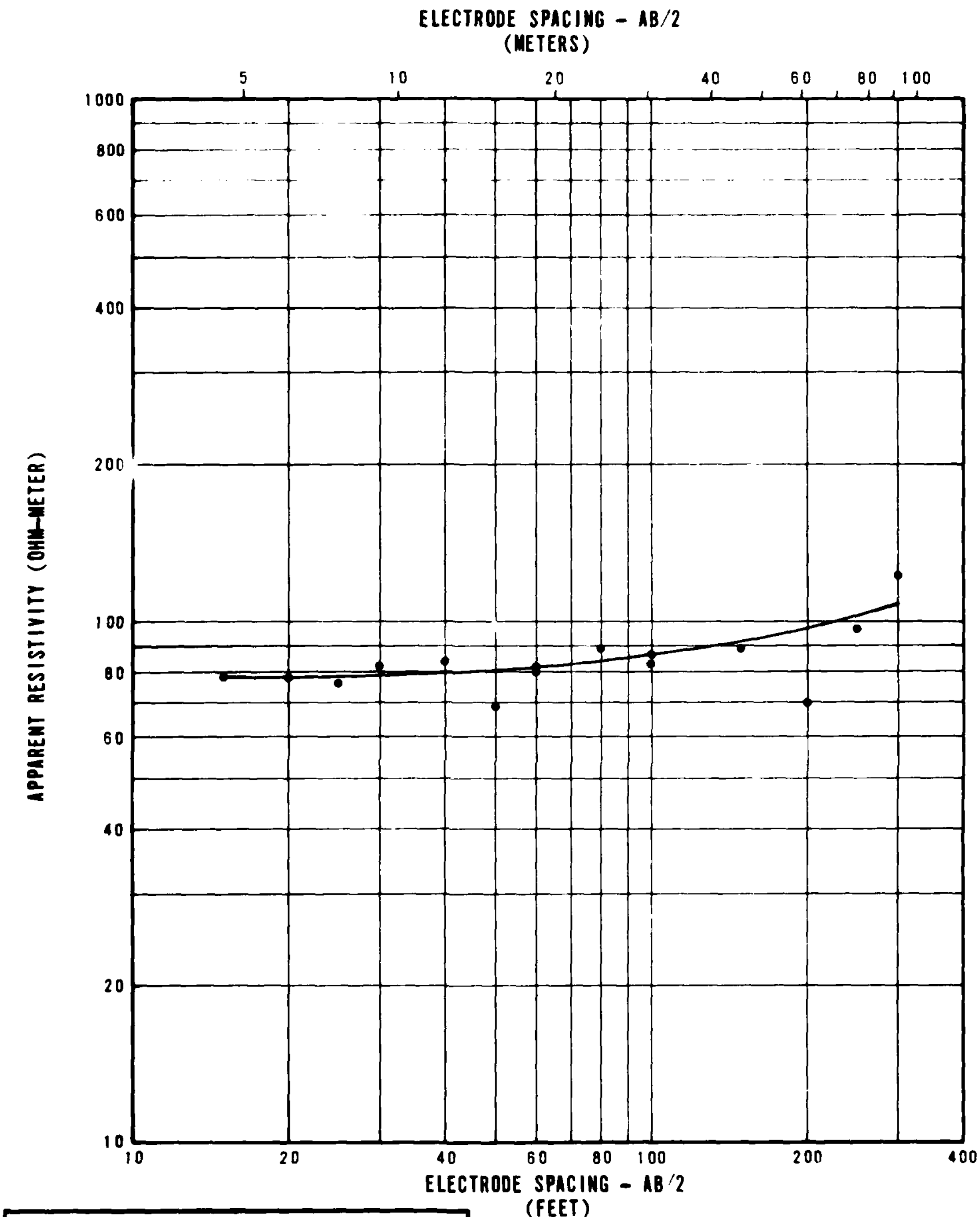
INTERPRETED MODEL		
LAYER DEPTH		RESISTIVITY VALUES
FEET	METERS	OHM-METER
0	0	210
10	3	140
155	47	290

RESISTIVITY SOUNDING LP-R-5
SOUNDING CURVE AND INTERPRETATION
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 4-5

FUGRO NATIONAL, INC.



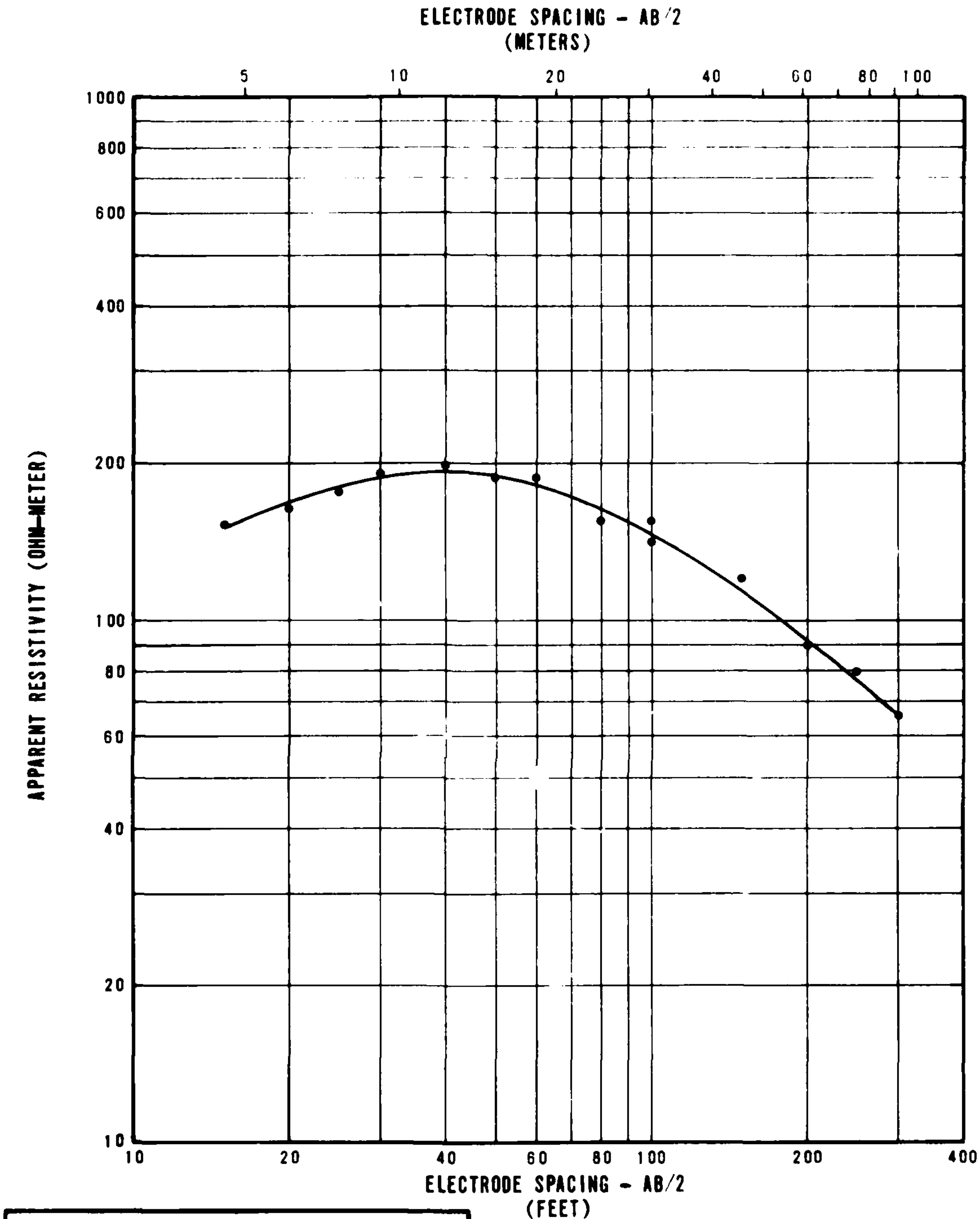
INTERPRETED MODEL		
LAYER DEPTH		RESISTIVITY VALUES
FEET	METERS	OHM-METER
0	0	80
77	23	120

RESISTIVITY SOUNDING LP-R-6
SOUNDING CURVE AND INTERPRETATION
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 4-6

FUGRO NATIONAL, INC.



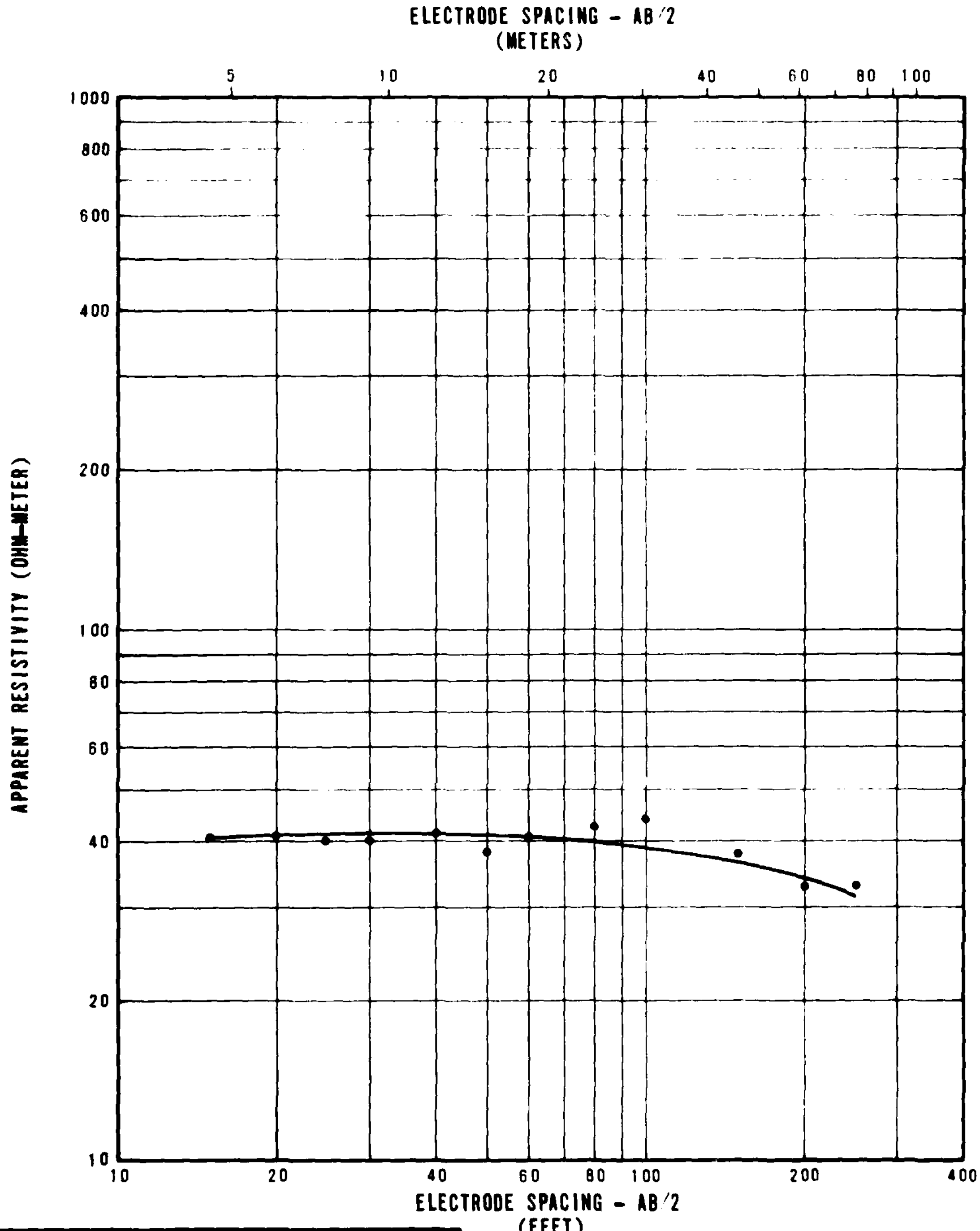
INTERPRETED MODEL		
LAYER DEPTH		RESISTIVITY VALUES
FEET	METERS	OHM-METER
0	0	130
7	2	230
41	12	60

RESISTIVITY SOUNDING LP-R-7
SOUNDING CURVE AND INTERPRETATION
VERIFICATION SITE, LA POSA COP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 4-7

FUGRO NATIONAL, INC.



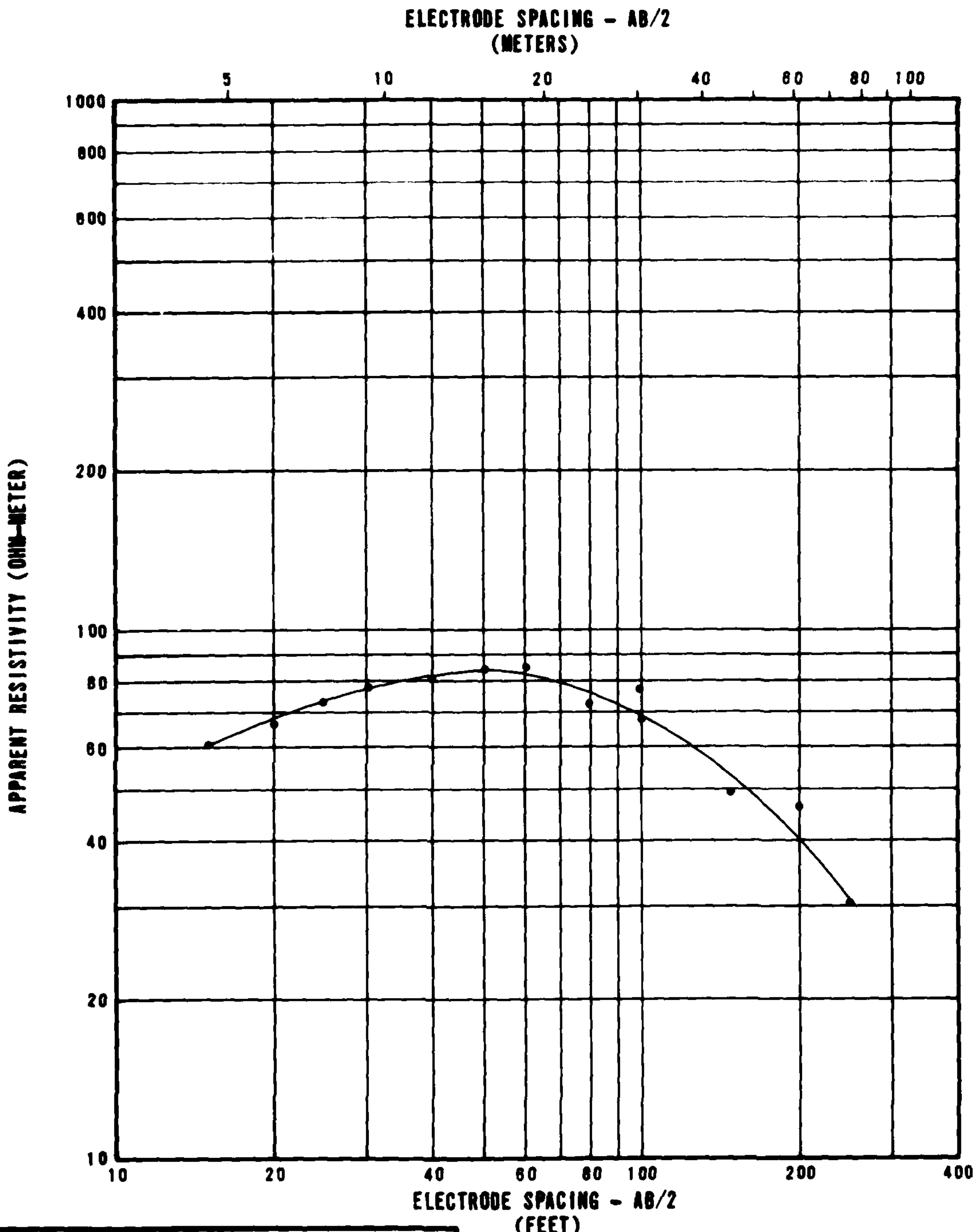
INTERPRETED MODEL		
LAYER DEPTH		RESISTIVITY VALUES
FEET	METERS	OHM-METER
0	0	40
109	33	25

RESISTIVITY SOUNDING LP-R-8
SOUNDING CURVE AND INTERPRETATION
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 4-8

FUGRO NATIONAL, INC.



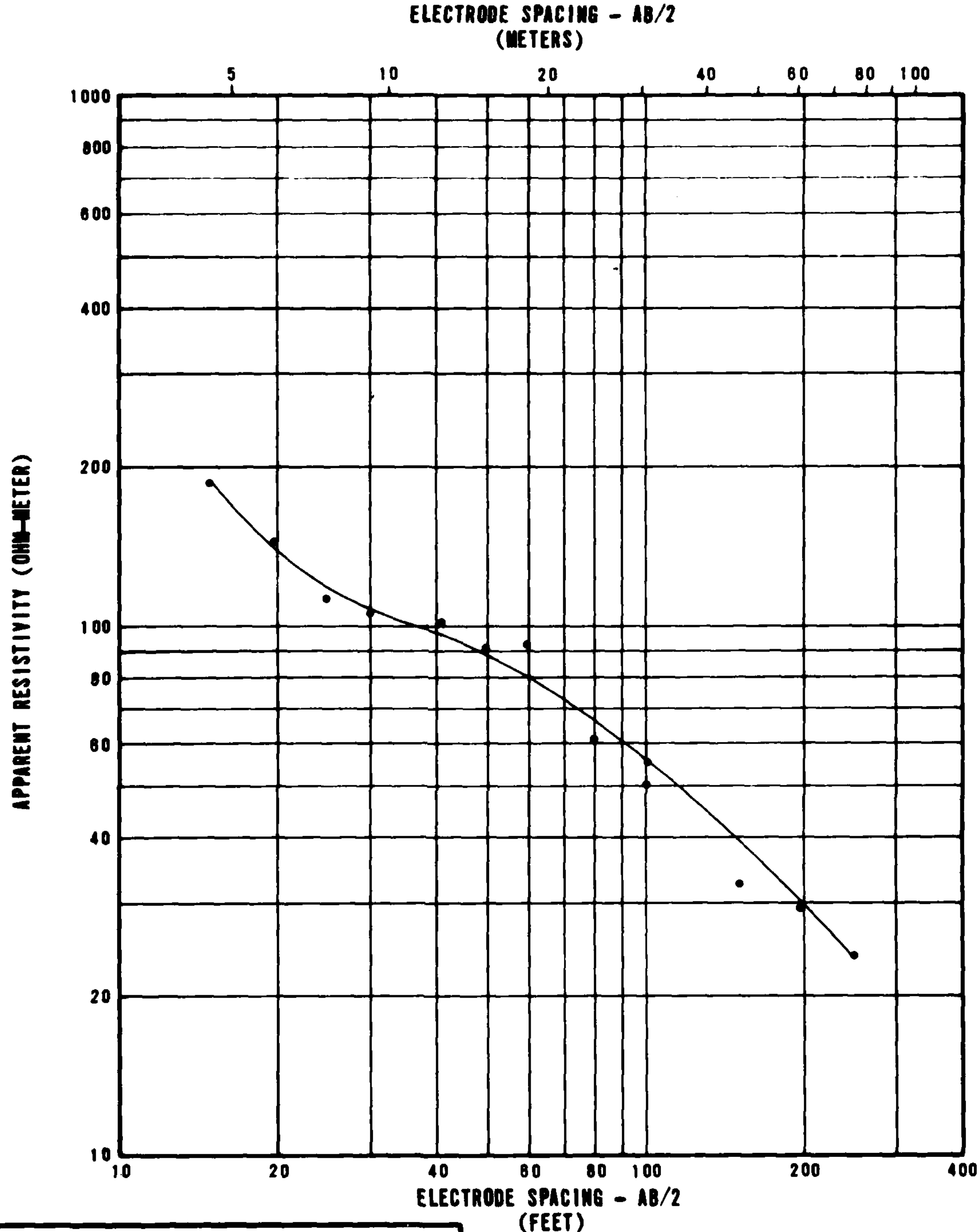
INTERPRETED MODEL		
LAYER DEPTH		RESISTIVITY VALUES
FEET	METERS	OHM-METER
0	0	55
9	3	110
52	16	25

RESISTIVITY SOUNDING LP-R-9
SOUNDING CURVE AND INTERPRETATION
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 4-9

FUGRO NATIONAL, INC.



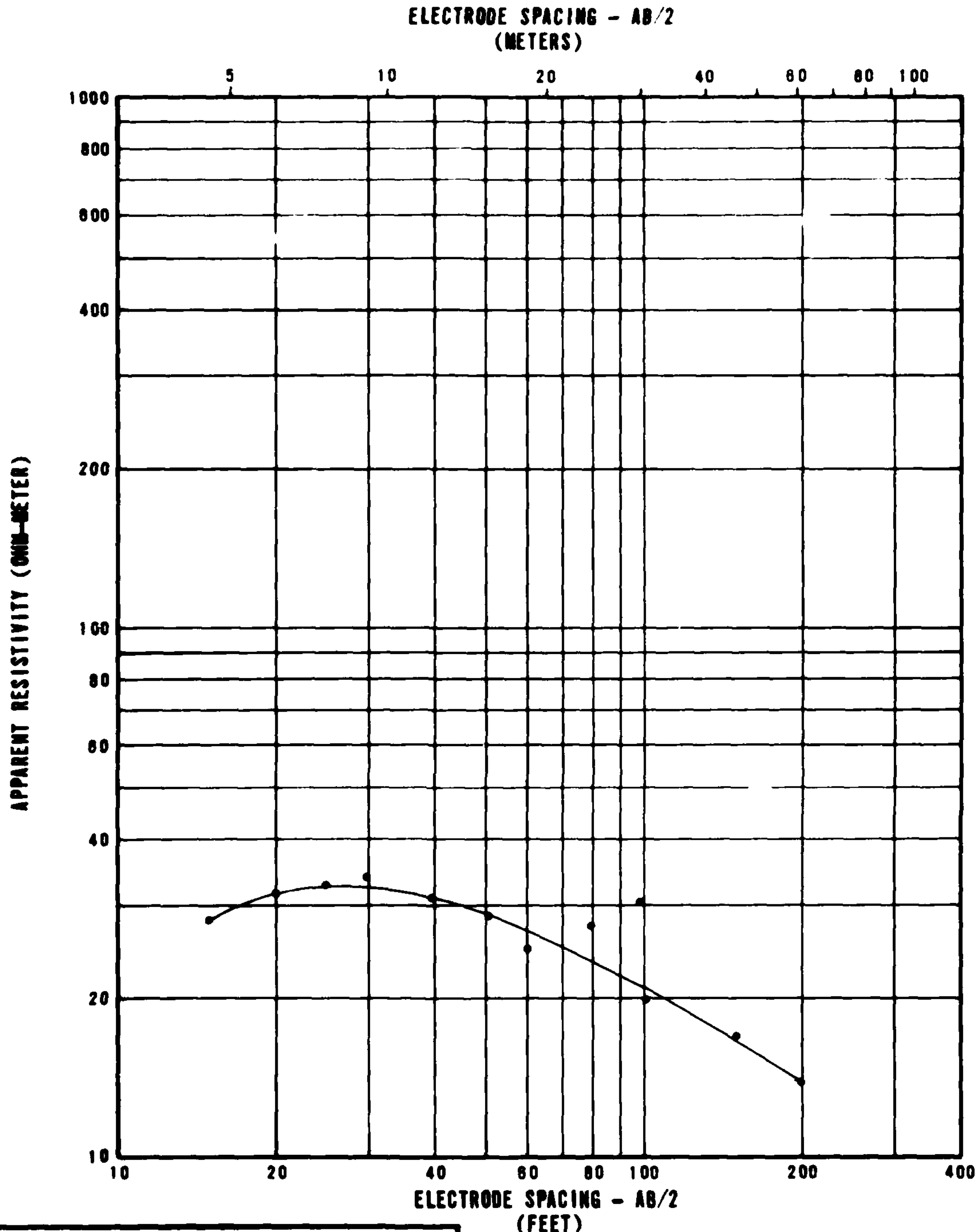
INTERPRETED MODEL		
LAYER DEPTH		RESISTIVITY VALUES
FEET	METERS	OHM-METER
0	0	310
7	2	85
47	14	35
122	37	14

RESISTIVITY SOUNDING LP-R-10
SOUNDING CURVE AND INTERPRETATION
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 4-10

FUGRO NATIONAL, INC.



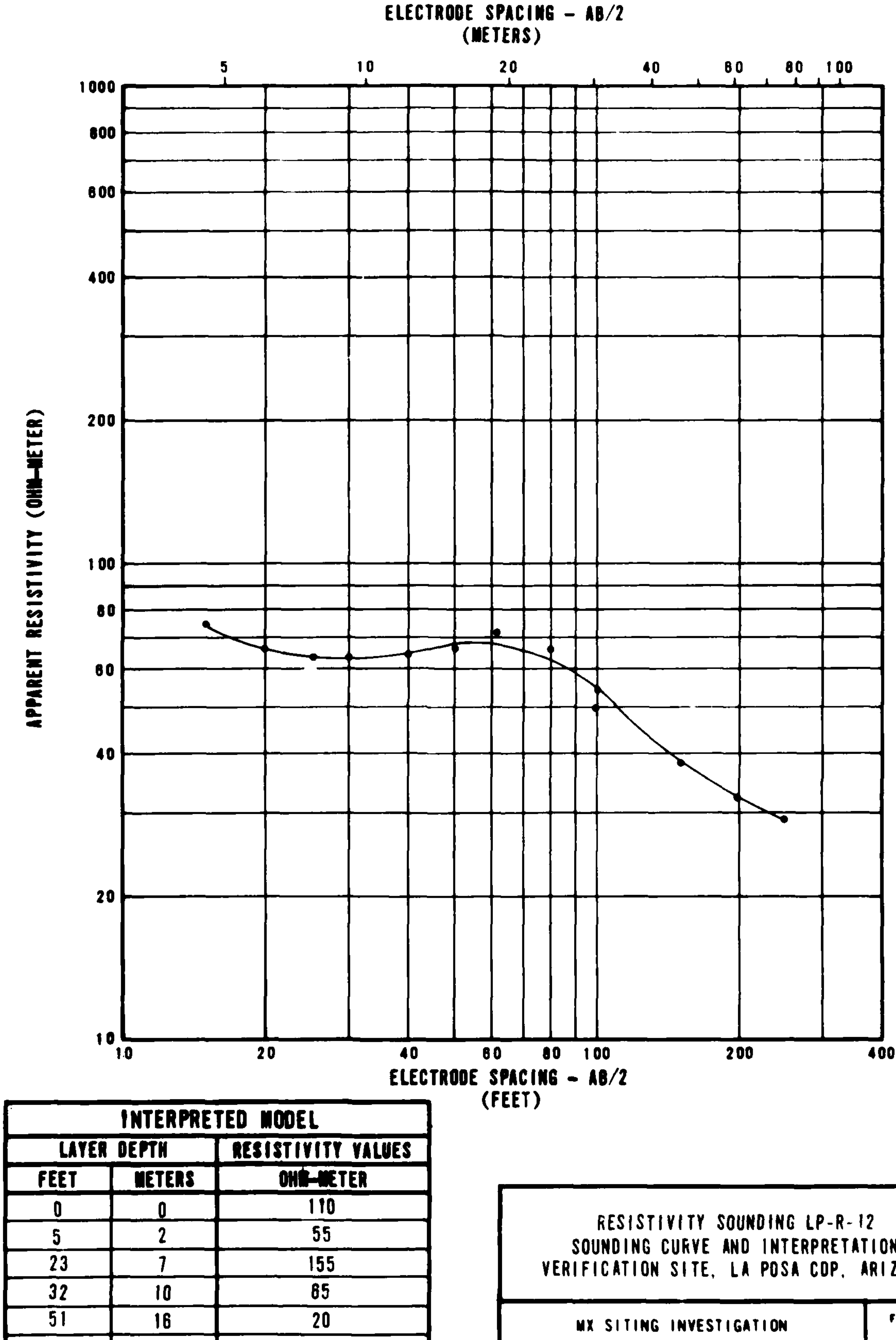
INTERPRETED MODEL		
LAYER DEPTH		RESISTIVITY VALUES
FEET	METERS	OHM-METER
0	0	20
5	2	40
29	9	13

RESISTIVITY SOUNDING LP-R-11
SOUNDING CURVE AND INTERPRETATION
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 4-11

FUGRO NATIONAL, INC.



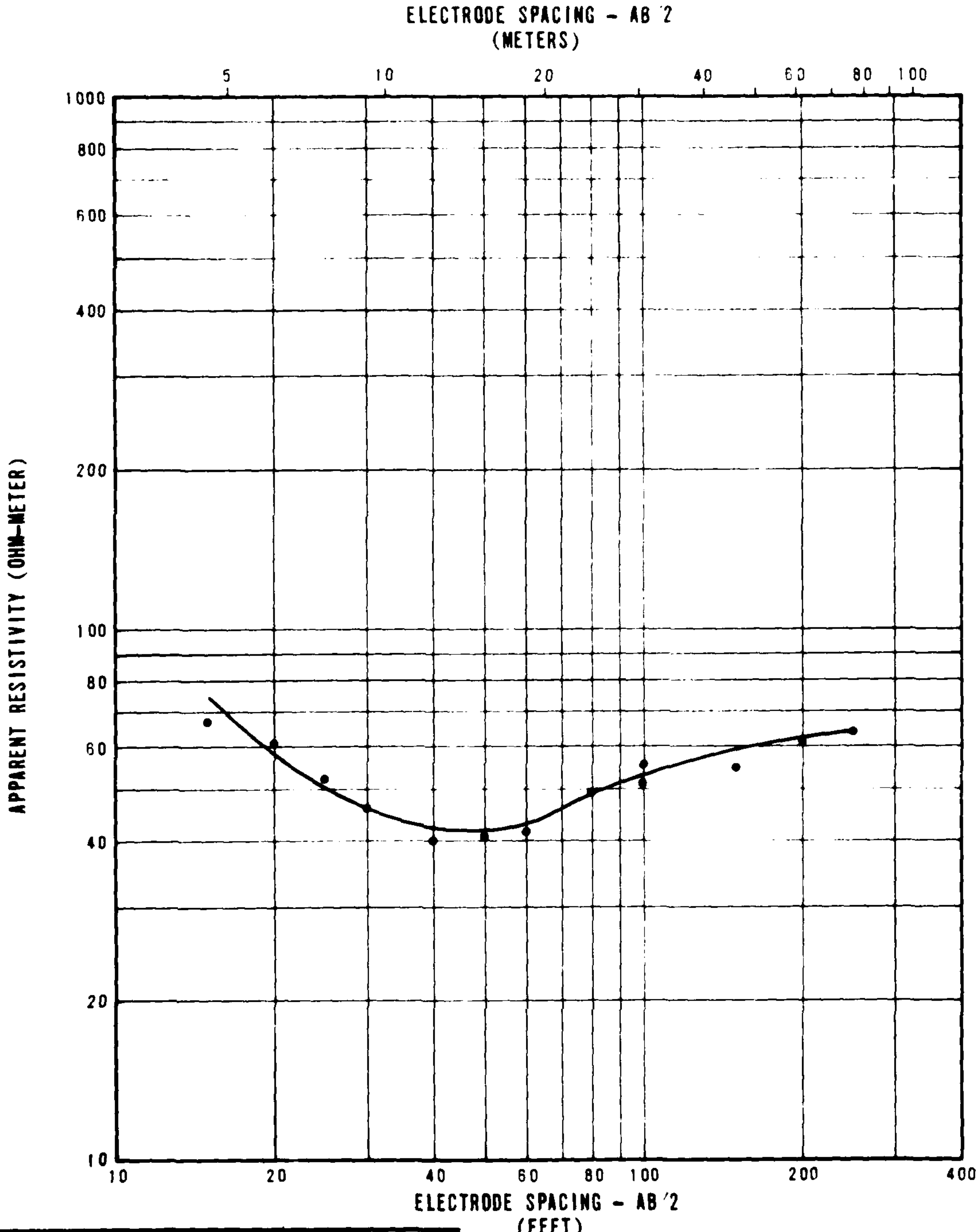
INTERPRETED MODEL		
LAYER DEPTH		RESISTIVITY VALUES
FEET	METERS	OHM-METER
0	0	110
5	2	55
23	7	155
32	10	65
51	16	20

RESISTIVITY SOUNDING LP-R-12
SOUNDING CURVE AND INTERPRETATION
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 4-12

FUGRO NATIONAL, INC.



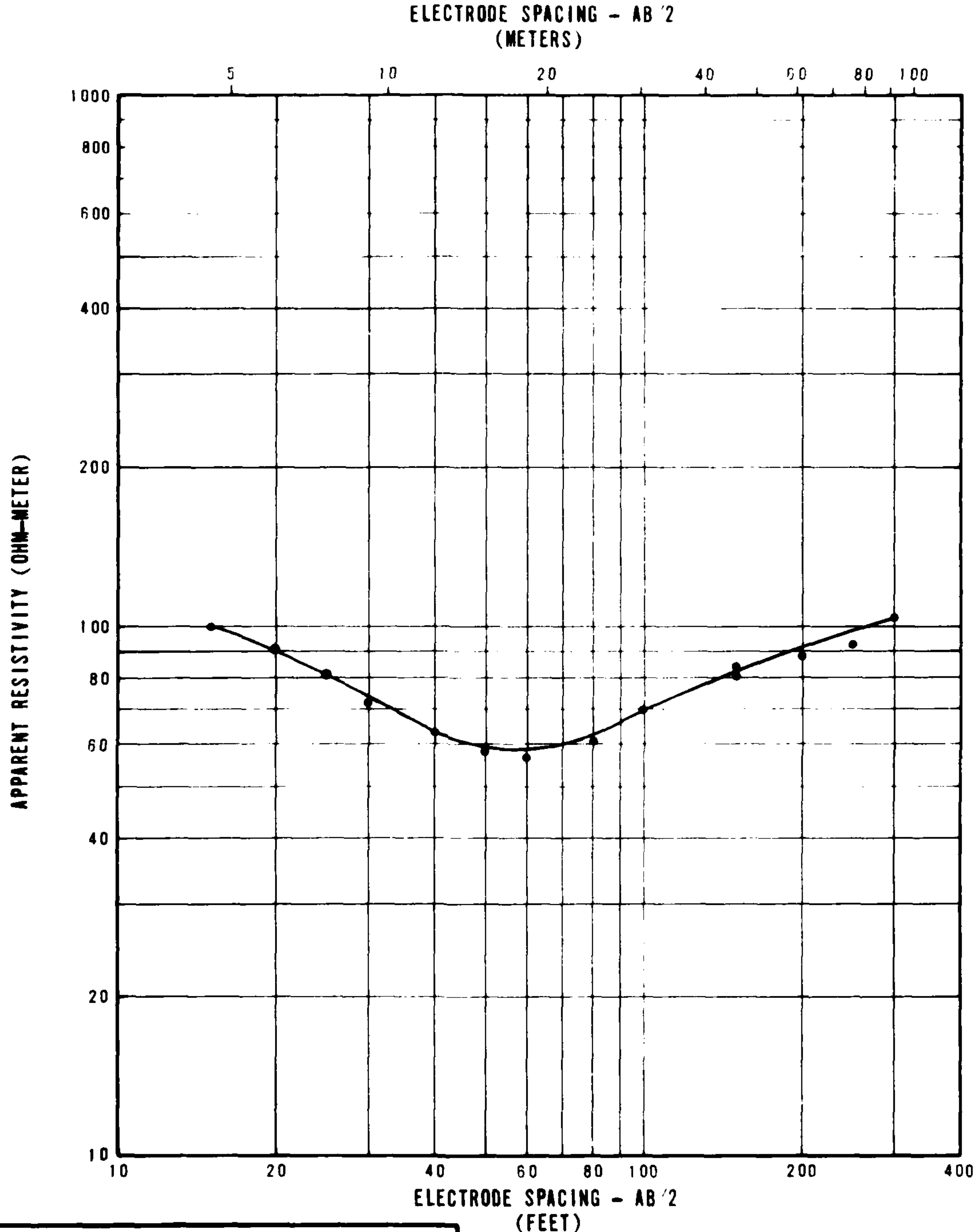
INTERPRETED MODEL		
LAYER DEPTH		RESISTIVITY VALUES
FEET	METERS	OHM-METER
0	0	100
7	2	35
42	13	95
80	24	60

RESISTIVITY SOUNDING LP-R-13
SOUNDING CURVE AND INTERPRETATION
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 4-13

FUGRO NATIONAL, INC.



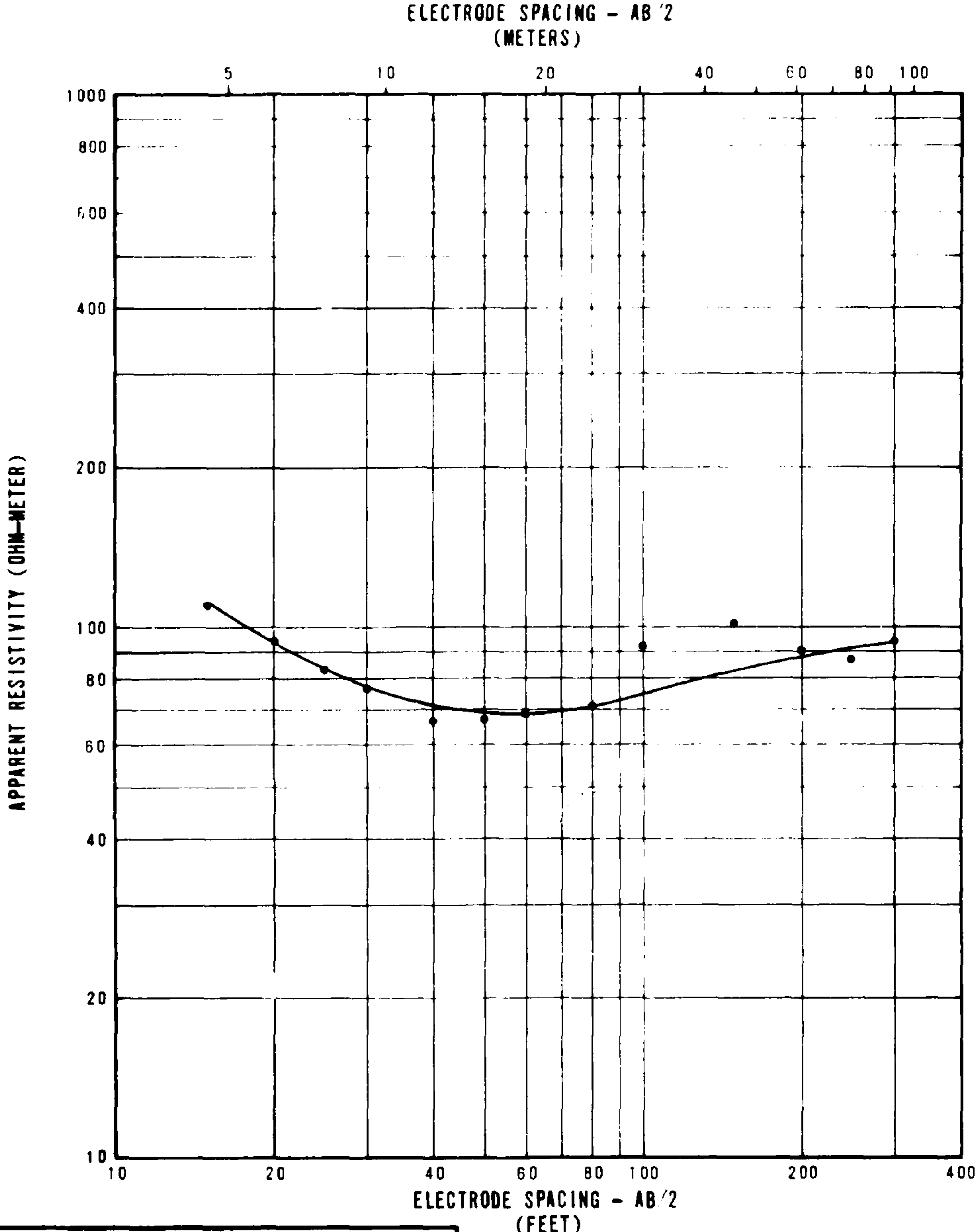
INTERPRETED MODEL		
LAYER DEPTH		RESISTIVITY VALUES
FEET	METERS	OHM-METER
0	0	105
12	4	45
61	19	280
83	25	120

RESISTIVITY SOUNDING LP-R-14
SOUNDING CURVE AND INTERPRETATION
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 4-14

FUGRO NATIONAL, INC.



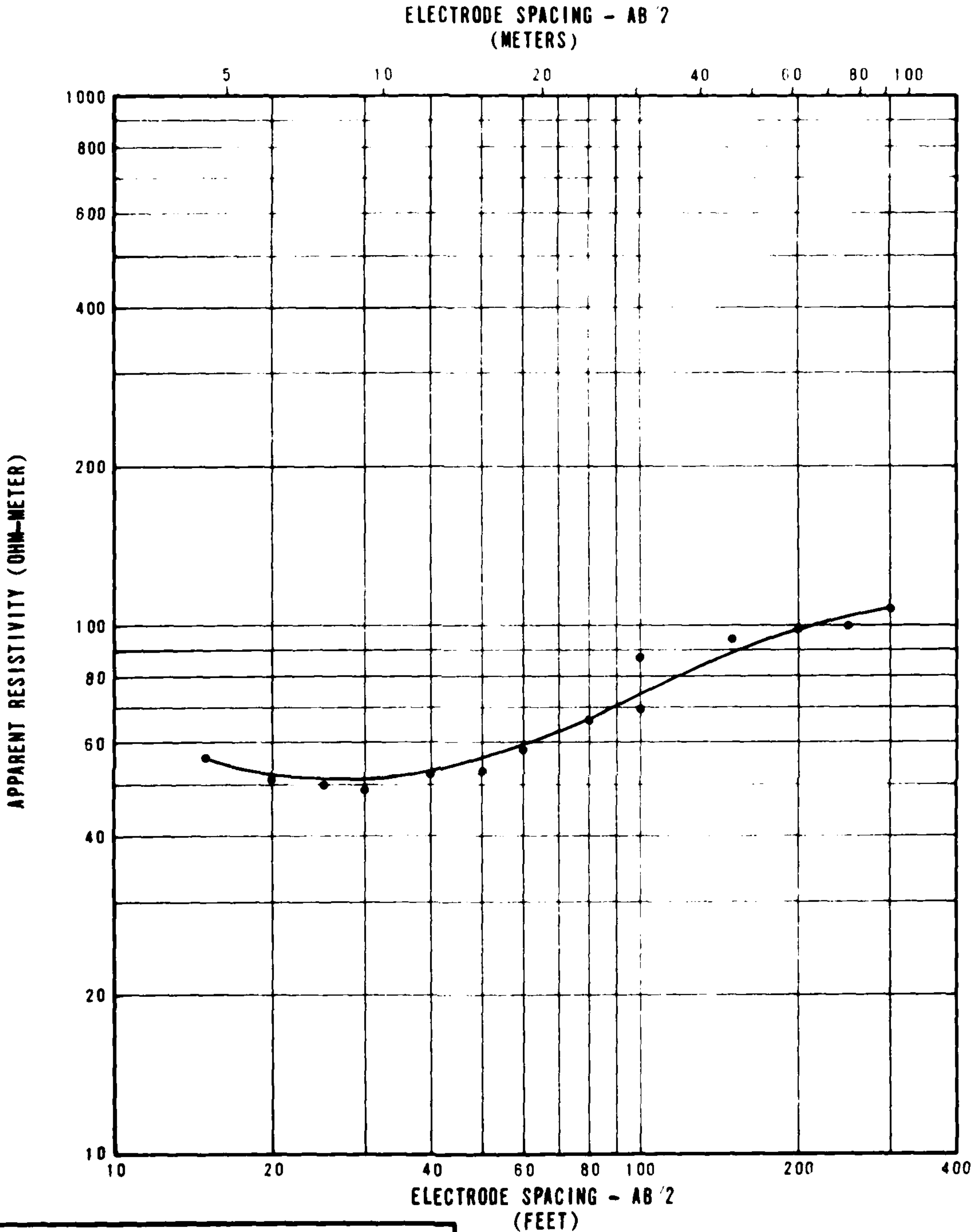
INTERPRETED MODEL		
LAYER DEPTH		RESISTIVITY VALUES
FEET	METERS	OHM-METER
0	0	140
8	2	65
42	13	95

RESISTIVITY SOUNDING LP-R-15
SOUNDING CURVE AND INTERPRETATION
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE
4-15

FUGRO NATIONAL, INC.



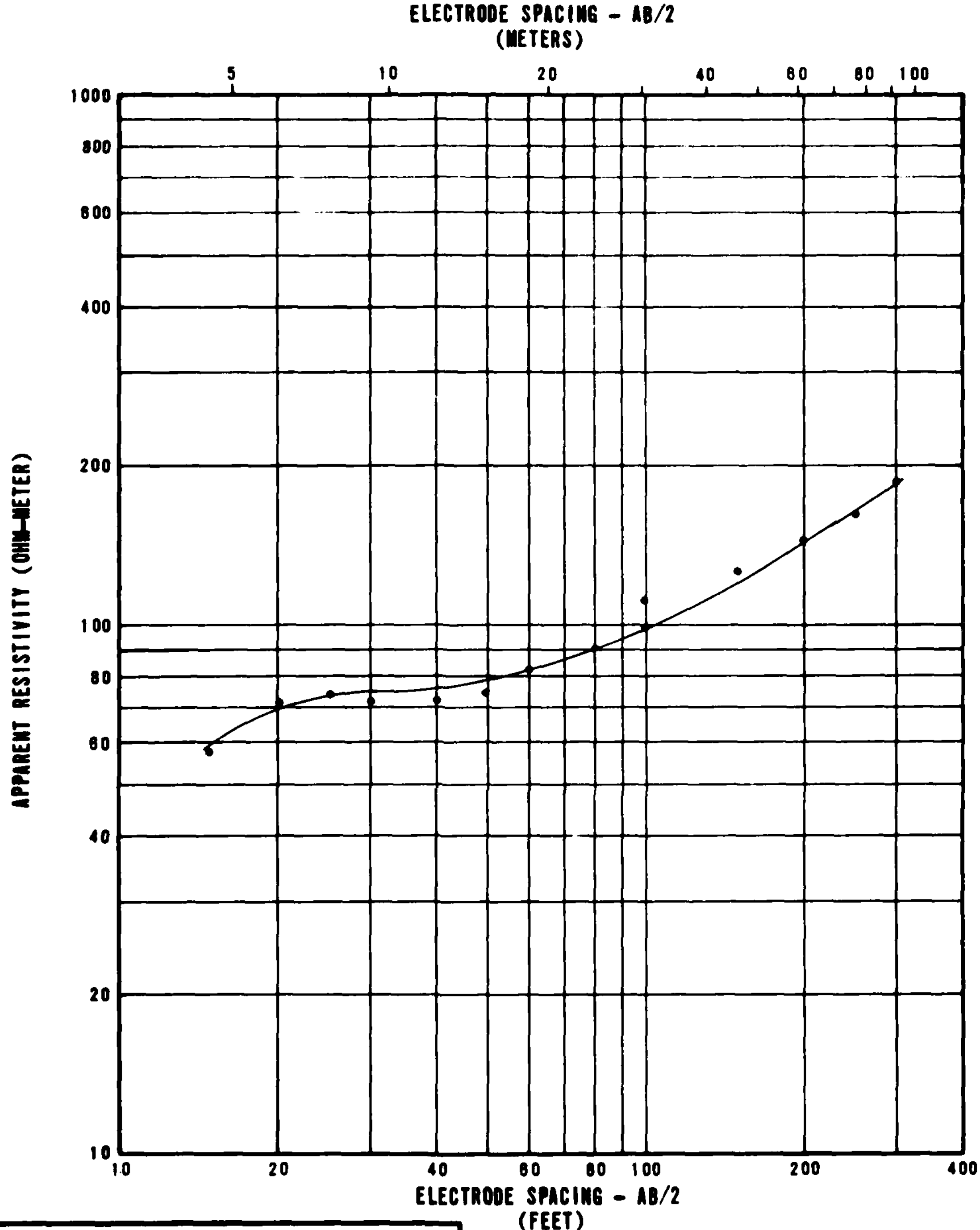
INTERPRETED MODEL		
LAYER DEPTH		RESISTIVITY VALUES
FEET	METERS	OHM-METER
0	0	60
12	4	40
32	10	130

RESITIVITY SOUNDING LP-R-16
SOUNDING CURVE AND INTERPRETATION
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 4-16

FUGRO NATIONAL, INC.



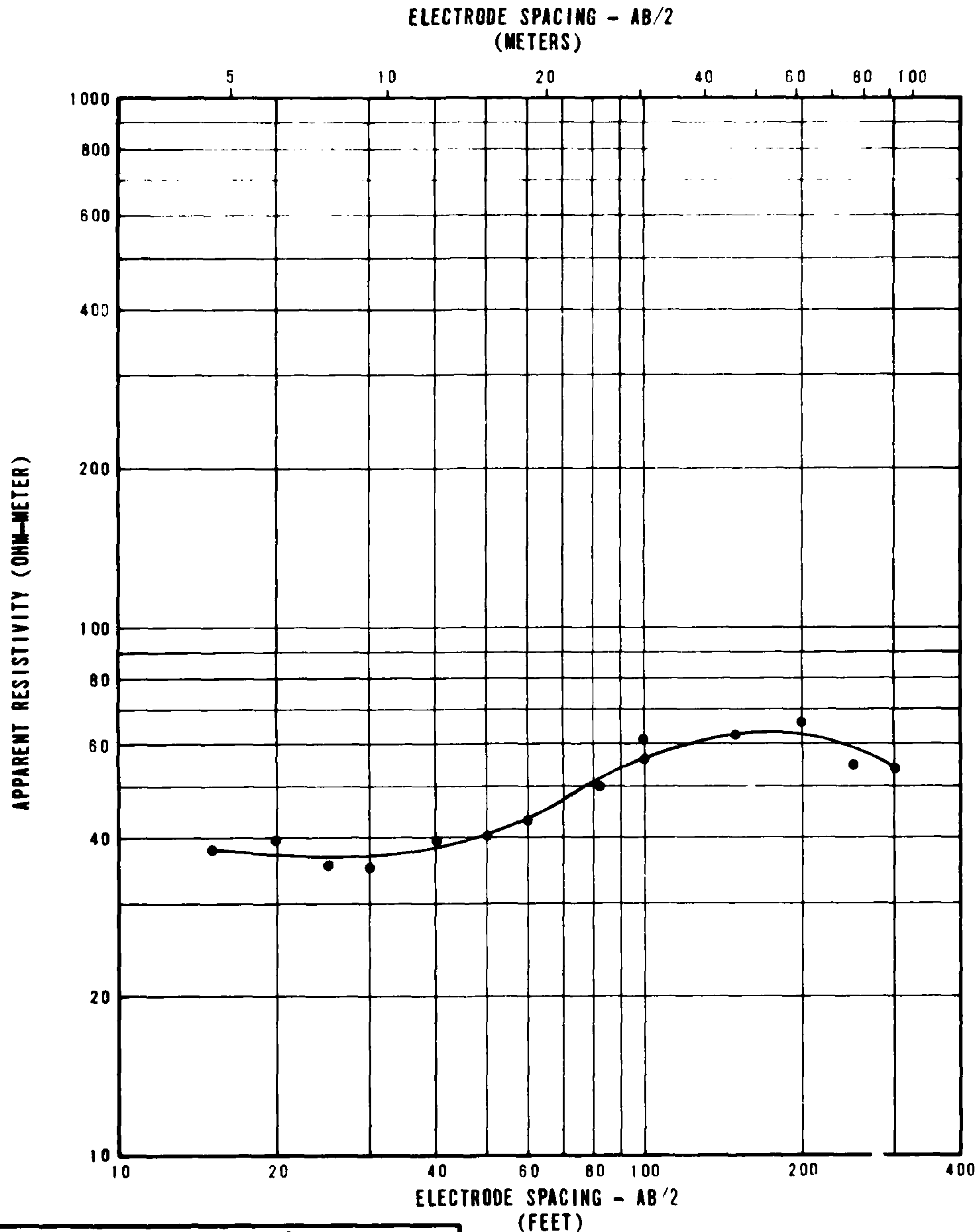
INTERPRETED MODEL		
LAYER DEPTH		RESISTIVITY VALUES
FEET	METERS	OHM-METER
0	0	40
5	2	90
26	8	75
69	21	310

RESISTIVITY SOUNDING LP-R-17
SOUNDING CURVE AND INTERPRETATION
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 4-17

FUGRO NATIONAL, INC.



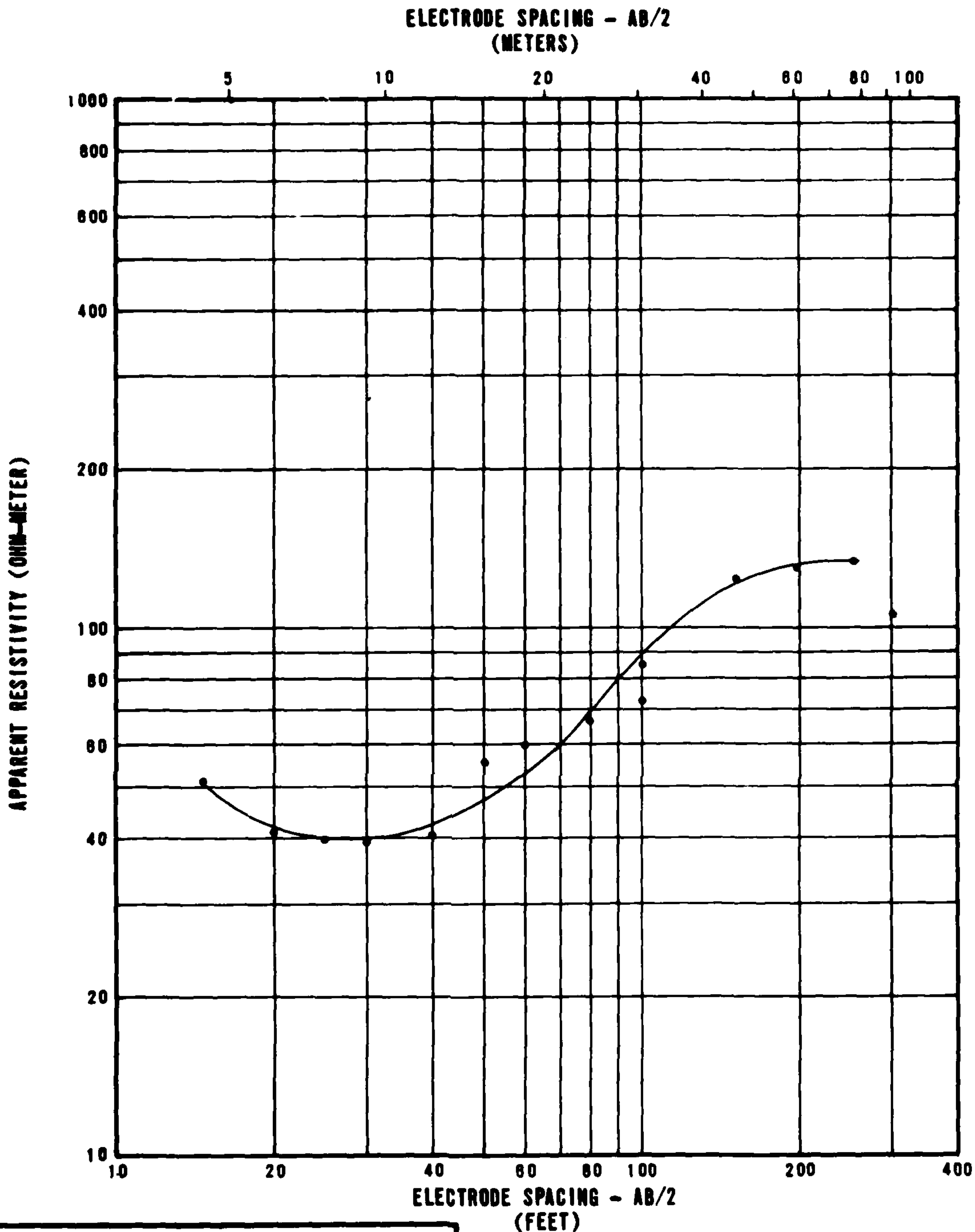
INTERPRETED MODEL		
LAYER DEPTH		RESISTIVITY VALUES
FEET	METERS	OHM-METER
0	0	45
51	16	130
108	33	30

RESISTIVITY SOUNDING LP-R-18
SOUNDING CURVE AND INTERPRETATION
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE
4-18

FUGRO NATIONAL, INC.



INTERPRETED MODEL		
LAYER DEPTH		RESISTIVITY VALUES
FEET	METERS	OHM-METER
0	0	60
7	2	30
35	11	440
84	26	170

RESISTIVITY SOUNDING LP-R-19
SOUNDING CURVE AND INTERPRETATION
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 4-19

FUGRO NATIONAL, INC.

SECTION 5.0

GRAVITY DATA

EXPLANATIONS OF GRAVITY DATA

Gravity data were not available in time (prior to June 1979) for incorporation into this report. A supplemental report containing gravity data and results will be issued at a later date.

SECTION 6.0

BORING LOGS

EXPLANATIONS OF BORING, TRENCH, AND TEST PIT LOGS

All data from borings, trenches, and test pits are presented on standard Fugro National logs in Sections 6.0 and . The following explanations are provided as a key to the logs.

A. Designations - Borings, trenches, and test pits are identified as follows:

LP-B-1
LP - abbreviation for the site (e.g., LP-La Posa)
B - abbreviation for activity (e.g., B-boring, T-trench, P-test pit)
1 - number of activity

B. Sample Type - Different sampling techniques were used and the symbols are explained at the bottom of the boring logs. For details of sampling techniques, see Section A5.0 of Appendix A in Volume I. Horizontal lines, to scale, indicate the depth where sampling was attempted.

C. Percent Recovery - The numbers shown represent the ratio (in percent) of the soil sample recovered in the sampler to the full penetration of the sampler.

D. N Value - Corresponds to standard penetration resistance, which is number of blows required to drive a standard split-spoon sampler for the second and third of three 6-inch (15 cm) increments with a 140-pound (63.5 kg) hammer falling 30 inches (76 cm) (ASTM D 1586-67).

E. Depth - Corresponds to depth below ground surface in meters and feet.

F. Lithology - Graphic representation of the soil and rock types.

G. USCS - Unified Soil Classification System (see Table 6-1 for complete details) symbols.

H. Soil Description - Except in cases where samples were classified based on laboratory test data, the descriptions are based on visual classification. The procedures outlined in ASTM D 2487-69, Classification of Soils for Engineering Purposes, and D 2488-69, Description of Soils (Visual-Manual Procedure) were followed. Solid lines across the column indicate known change in strata at the depth shown.

Definitions of some of the terms and criteria to describe soils and conditions encountered during the exploration follow.

Gradation : A coarse-grained soil is well graded if it has a wide range in grain size and substantial amounts of most intermediate particle sizes.

Poorly graded indicates that the soil consists predominantly of one size (uniformly graded) or has a wide range of sizes with some intermediate sizes obviously missing (gap-graded).

Moisture :	Dry	- no feel of moisture
	Slightly Moist	- much less than normal moisture
	Moist	- normal moisture for soil
	Very Moist	- much greater than normal moisture
	Wet	- for soils below the water table (if known)

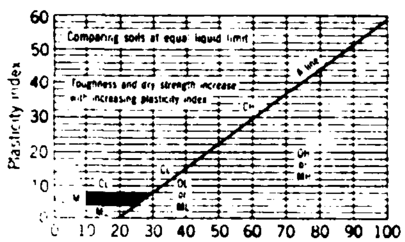
Major Divisions			Field Identification Procedures (Excluding particles larger than 3 in. and basing fractions on estimated weights)	Group Symbols[a]	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria
Coarse-grained soils. More than half of material is *larger* than No. 200 sieve size[b] (The No. 200 sieve size is about the smallest particle visible to naked eye)	Gravels. More than half of coarse fraction is larger than No. 4 sieve size (For visual classification, the ¼ in. size may be used as equivalent to the No. 4 sieve size)	Clean gravels (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	*GW*	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name, indicate approximate percentages of sand and gravel, maximum size, angularity, surface condition, and hardness of the coarse grains, local or geologic name and other pertinent descriptive information, and symbols in parentheses	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing	*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for *GW*
		Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)	*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures		Atterberg limits below "A" line, or *PI* less than 4. Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics	Atterberg limits above "A" line, with *PI* greater than 7
	Sands. More than half of coarse fraction is smaller than No. 4 sieve size	Clean sands (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes	*SW*	Well graded sands, gravelly sands, little or no fines	Example: *Silty sand*, gravelly, about 20% hard, angular gravel particles ½-in. maximum size, rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength, well compacted and moist in place, alluvial sand, (*SM*)	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing	*SP*	Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for *SW*
		Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)	*SM*	Silty sands, poorly graded sand-silt mixtures		Atterberg limits below "A" line or *PI* less than 5. Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*SC*	Clayey sands, poorly graded sand-clay mixtures		Atterberg limits below "A" line with *PI* greater than 7

Use grain size curve in identifying the fractions as given under field identification.

Determine percentages of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse grained soils are classified as follows:
Less than 5%: *GW, GP, SW, SP*
More than 12%: *GM, GC, SM, SC*
5% to 12%: *Borderline* cases requiring use of dual symbols

Identification Procedures on Fraction Smaller than No. 40 Sieve Size

Major Divisions		Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)	Group Symbols[a]	Typical Names	Information Required for Describing Soils
Fine-grained soils. More than half of material is *smaller* than No. 200 sieve size (The No. 200 sieve size is about the smallest particle visible to naked eye)	Silts and clays liquid limit less than 50	None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name, indicate degree and character of plasticity, amount and maximum size of coarse grains, colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses
		Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
		Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions
	Silts and clays liquid limit greater than 50	Slight to medium	Slow to none	Slight to medium	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	
		High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays	Example: *Clayey silt*, brown, slightly plastic, small percentage of fine sand, numerous vertical root holes, firm and dry in place, loess, (*ML*)
		Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity	
Highly Organic Soils		Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils	



Plasticity chart
for laboratory classification of fine grained soils

From Wagner, 1957.

[a] *Boundary classifications*. Soils possessing characteristics of two groups are designated by combinations of group symbols. For example *GW-GC*, well graded gravel-sand mixture with clay binder.

[b] All sieve sizes on this chart are U.S. standard.

Field Identification Procedure for Fine Grained Soils or Fractions

These procedures are to be performed on the minus No. 40 sieve size particles, approximately 1/64 in. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

Dilatancy (Reaction to shaking)

After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil soft but not sticky.

Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.

Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

Dry Strength (Crushing characteristics)

After removing particles larger than No. 40 sieve size, mould a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun or air drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic for clays of the *CH* group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

Toughness (Consistency near plastic limit)

After removing particles larger than the No. 40 sieve size, a specimen of soil about one-half inch cube in size, is moulded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eight inch in diameter. The thread is then folded and re-rolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.

After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clays of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.

Highly organic clays have a very weak and spongy feel at the plastic limit.

UNIFIED SOIL CLASSIFICATION SYSTEM

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 6-1

FUGRO NATIONAL, INC.

Consistency: Consistency descriptions of coarse-grained soils (GW, GP, GM, GC, SW, SP, SM, SC) are as follows.

Consistency	N Value (ASTM D 1586-67)
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	>50

Consistency descriptions of fine-grained soils (ML, CL, MH, CH,) are as follows:

Consistency	Shear Strength (ksf)	Shear Strength (kn/m^2)	Field Guide
Very Soft	0.25	12	Sample with height equal to twice the diameter, sags under own weight
Soft	0.25-0.50	12 - 24	Can be squeezed between thumb and forefinger
Firm	0.50-1.00	24-48	Can be molded easily with fingers
Stiff	1.00-2.00	48-96	Can be imprinted with slight pressure from fingers
Very Stiff	2.00-4.00	96-192	Can be imprinted with considerable pressure from fingers
Hard	over 4.00	over 192	Cannot be imprinted by fingers

Grain Shape: Angular - particles have sharp edges and relatively plane sides with unpolished surfaces.

Subangular - particles are similar to angular but have somewhat rounded edges.

Subrounded - particles exhibit nearly plane sides but have well-rounded corners and edges.

Rounded - particles have smoothly curved sides and no edges.

Calcareous : Containing calcium carbonate; presence of calcium carbonate is commonly identified on the basis of reaction with dilute hydrochloric acid.

Caliche : Soils cemented by porous calcium carbonate and/or other soluble minerals by upward-moving solutions.

Degree of Cementation: (Stages of development of caliche profile)

Stage	Gravelly Soils	Nongravelly Soils
I	Thin, discontinuous pebble coatings	Few filaments or faint coatings
II	Continuous pebble coatings, some interpebble fillings	Few to abundant nodules, flakes, filaments
III	Many interpebble fillings	Many nodules and internodular fillings
IV	Laminar horizon overlying plugged horizon	Increasing carbonate impregnation

Secondary Material : Example - Sand with trace to some silt

Trace - 5-12% (by dry weight)
Little - 13-20% (by dry weight)
Some - >20% (by dry weight)

Plasticity : Plasticity index is the range of water content, expressed as a percentage of the weight of the oven-dried soil, through which the soil is plastic. It is defined as the liquid limit minus the plastic limit. Descriptive ranges used on the logs include:

Nonplastic	(PI, 0 - 4)
Slightly Plastic	(PI, 4 - 15)
Medium Plastic	(PI, 15 - 30)
Highly Plastic	(PI, >30)

Cobbles and Boulders : A cobble is a rock fragment, usually rounded by weathering or abrasion, with an average diameter ranging between 3 and 12 inches (8 and 30 cm).

A boulder is a rock fragment, usually rounded by weathering or abrasion, with an average diameter of 12 inches (30 cm) or more.

I. Remarks - This column was provided on boring and trench logs for comments regarding drilling difficulty, number and size of cobbles or boulders encountered, trench wall stability, loss of drilling fluid in the boring, and other conditions encountered during drilling and excavations.

J. Dry Density and Moisture Content - The boring logs include a graphical display of laboratory test results for dry density (ASTM D 2937-71) in pounds per cubic foot and kilograms cubic meter and moisture content (ASTM D 2216-71) in percent from representative samples taken during drilling. The symbols are explained at the bottom of the boring logs.

K. Seive Analysis - The numbers represent the percentage by dry weight (ASTM D 422-63) of each of the following soil components:

GR - Gravel, rock particles that will pass a 3-inch (76 mm) sieve and are retained on No. 4 (4.75 mm) sieve.

SA - Sand, soil particles passing No. 4 sieve and retained on No. 200 (0.075 mm) sieve.

FI - Fines, silt or clay, soil particles passing No. 200 sieve.

L. Atterberg Limits (LL and PI) -

LL - Liquid Limit, the water content corresponding to the arbitrary limit between the liquid and plastic states of consistency of a soil (ASTM D 423-66).

PL - Plastic Limit, the water content corresponding to an arbitrary limit between the plastic and the semisolid state of consistency of a soil (ASTM D 424-59).

PI - Plasticity Index, numerical difference between the liquid limit (LL) and the plastic limit (PL) indicating the range of moisture content within which a soil-water mixture is plastic.

NP - Nonplastic.

M. Miscellaneous Information -

Elevations - indicated elevations on the logs are estimated from topographic maps of the study area, within an accuracy of half the contour interval.

Surficial Geologic Unit - indicates the surficial geologic unit in which the activity is located.

Date Drilled - indicates the period from beginning to completion of the activity.

Drilling Method - signifies the type of drilling procedure used such as rotary wash.

Hole Diameter - nominal size of boring drilled.

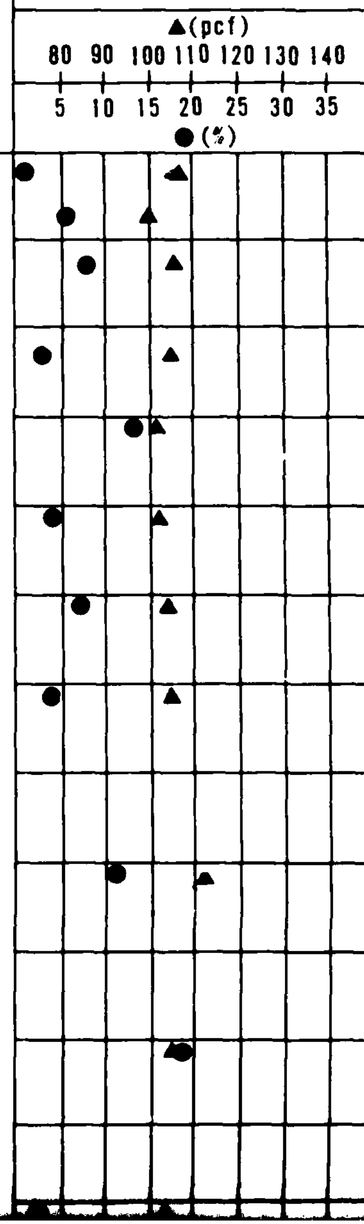
Water Level - indicates depth from ground surface to water table where encountered.

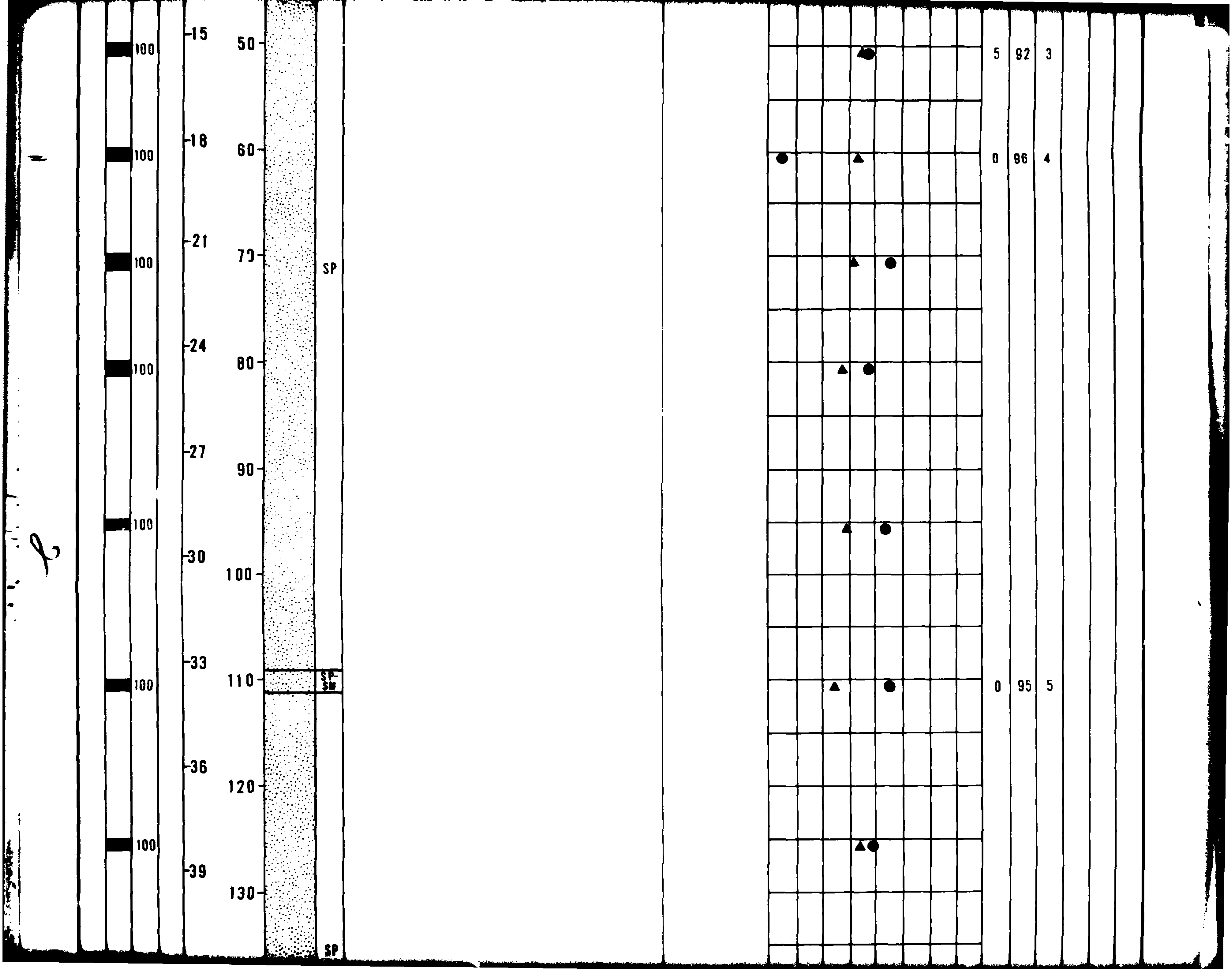
Trench Length - length at ground surface of final trench excavation.

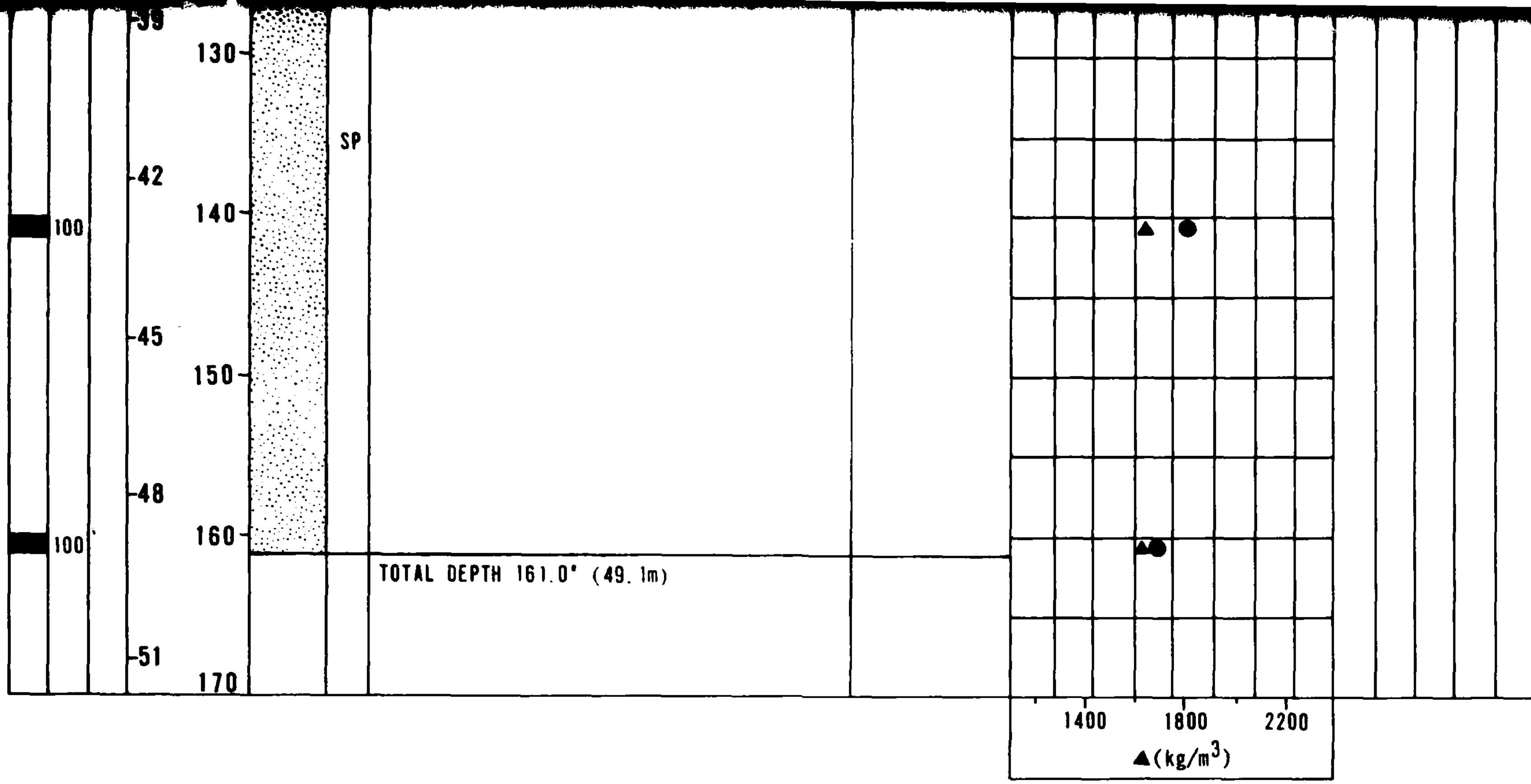
Trench Orientation - bearing of longitudinal trench centerline.

CHECKED BY ____ APPROVED BY ____

SAMPLE TYPE	% RECOVERY	N VALUE	DEPTH METERS	DEPTH FEET	USCS	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
	76		0	0	SP-SM	SAND, yellow brown, fine to medium, poorly graded, medium dense, subrounded; trace silt						
	100											
	100				SM	SILTY SAND, yellow brown, fine to medium, poorly graded, dense, subangular to subrounded, calcareous; little silt; trace fine gravel.		10	72	18		
	100		3	10	SP	SAND, light brown, fine to medium, poorly graded, medium dense to dense, subangular to subrounded, calcareous; trace fine gravel (10.5'-13.9' and 48.0'-54.0'); trace silt (26.0'-39.0' and 109.0'-111.0'); occasional cemented lenses throughout.		7	90	3		
	100											
	100		6	20				0	99	1		
	100											
	100		9	30	SP-SM			0	92	8		
	100		12	40								
	100		15	50				5	92	3		




100
100
100
100
100
100
100
-15
-18
-21
-24
-27
-30
-33
-36
-39
50
60
70
80
90
100
110
120
130
SP
SP-SM
SP
5 92 3
0 96 4
0 95 5



EXPLANATION

- FUGRO DRIVE SAMPLE
- BULK SAMPLE
- PITCHER TUBE SAMPLE
- STANDARD PENETRATION TEST SAMPLE
- CORE SAMPLE
- N - STANDARD PENETRATION RESISTANCE
- ▲ - DRY UNIT WEIGHT (ASTM: D-2937-71)
- ● - MOISTURE CONTENT (ASTM: D-2216-71)
- NR - NO RECOVERY

BORING DETAILS

ELEVATION	: 800' (244m)
SURFICIAL GEOLOGIC UNIT	: A3d
DATE DRILLED	: 21—22 February 1979
DRILLING METHOD	: Rotary Wash
HOLE DIAMETER	: 4 7/8" (124mm)
WATER LEVEL	: Not Encountered

LOG OF BORING LP-B-1
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 6-1

FUGRO NATIONAL, INC.

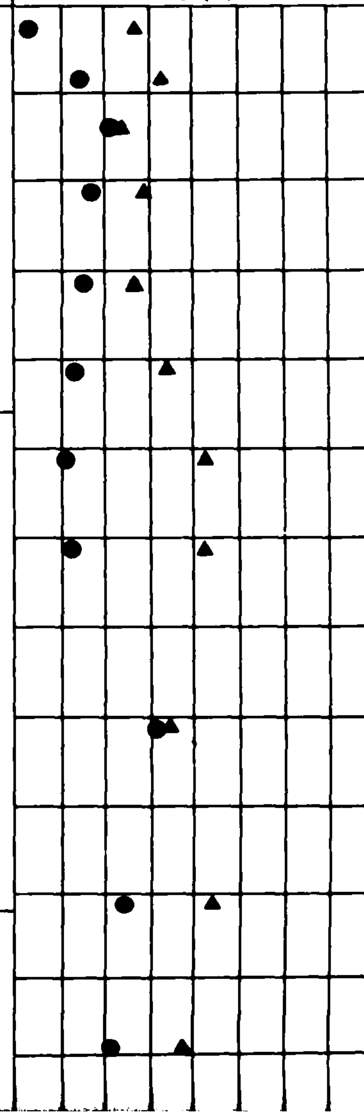
AFV-00

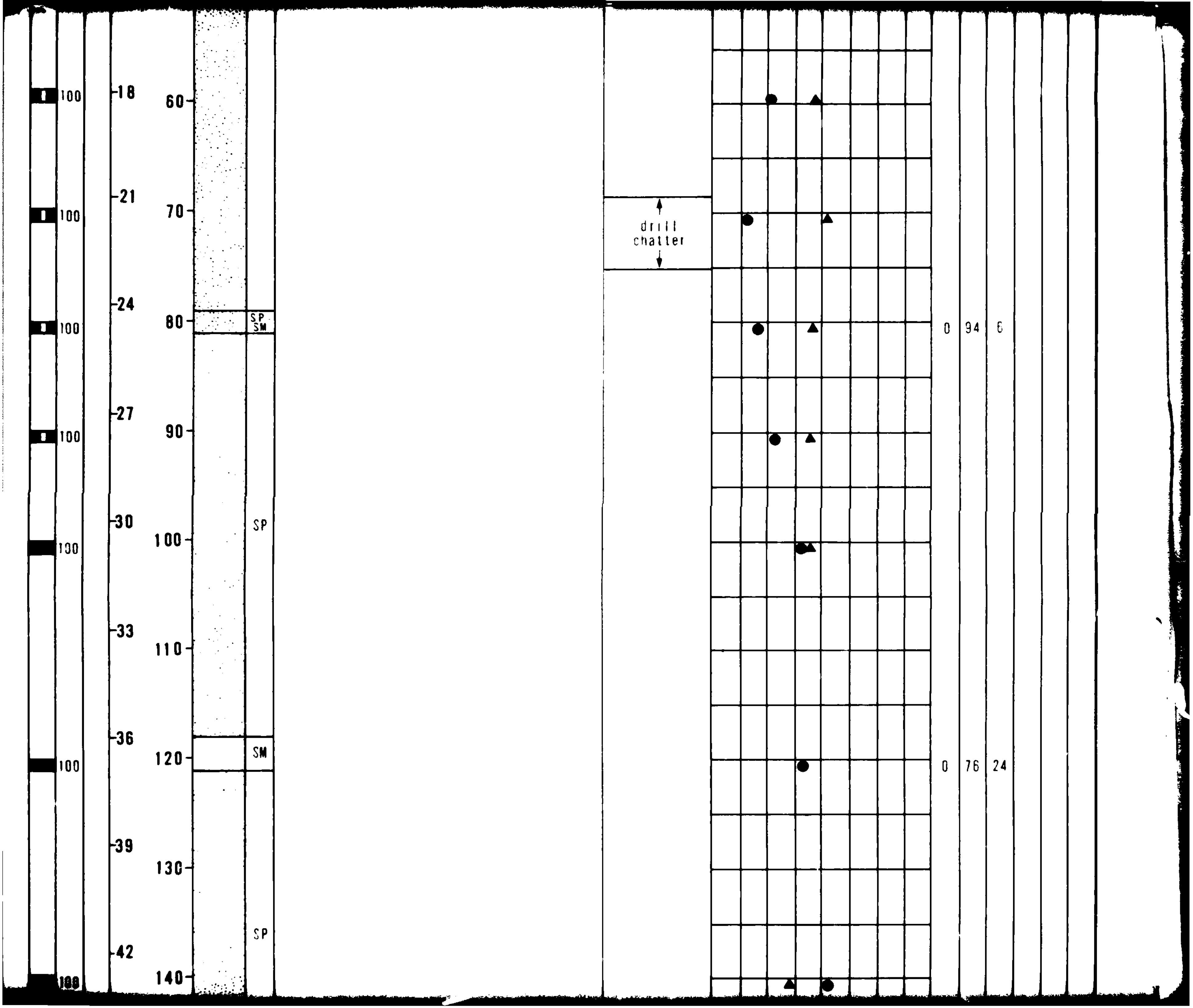
3

CHECKED BY ______ APPROVED BY ______

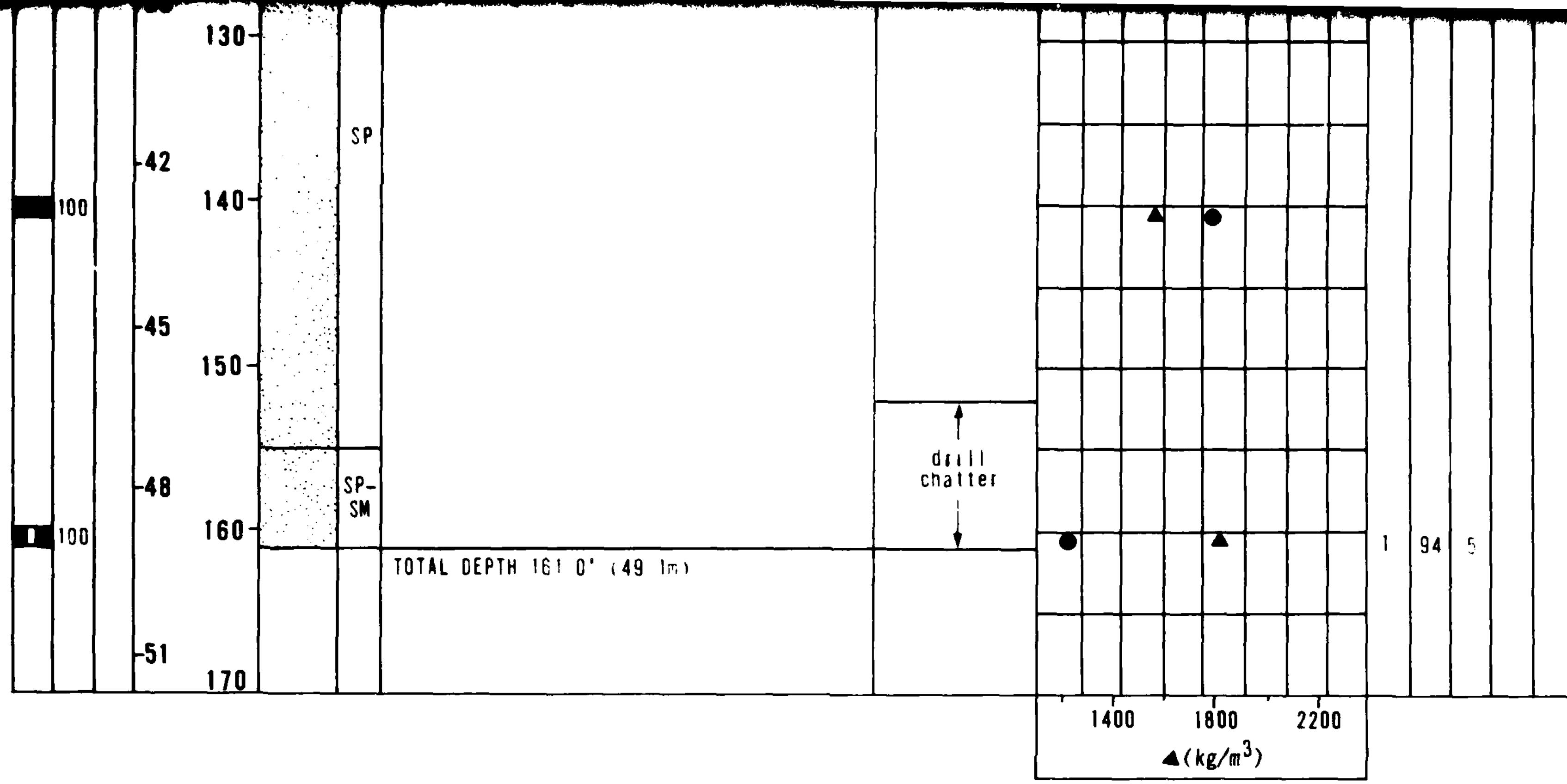
% RECOVERY	N VALUE	DEPTH METERS	DEPTH FEET	USCS	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
46		0	0	SM	SILTY SAND, yellow brown, fine to medium, poorly graded, medium dense to dense subangular to subrounded, calcareous; occasional moderately to well cemented layers; little to some silt.						
89							2	78	20		
100											
100		3	10								
100							0	76	24		
100		6	20								
100				SP	SAND, light brown, fine to medium, poorly graded, dense to very dense, subangular to rounded, calcareous; occasional well cemented layers between (76.0' 161.0'); trace silt (79.0'-81.0') and (155.0'-161.0'); some silt (118.0'-121.0'); occasional layers with traces of fine gravel	irregular drill chatter	3	95	2		
100		9	30								
100		12	40								
100		15	50				1	96	3		
100		18	60								

▲(pcf) 80 90 100 110 120 130 140
●(%) 5 10 15 20 25 30 35





100
100
100
100
100
100
100
-18
-21
-24
-27
-30
-33
-36
-39
-42
60
70
80
90
100
110
120
130
140
SP
SM
SP
SM
SP
drill chatter
0
94
6
0
76
24



EXPLANATION

- FUGRO DRIVE SAMPLE
- BULK SAMPLE
- PITCHER TUBE SAMPLE
- STANDARD PENETRATION TEST SAMPLE
- CORE SAMPLE

N - STANDARD PENETRATION RESISTANCE

▲ - DRY UNIT WEIGHT (ASTM: D-2937-71)

● - MOISTURE CONTENT (ASTM: D-2216-71)

NR - NO RECOVERY

BORING DETAILS

ELEVATION	: 900' (274m)
SURFICIAL GEOLOGIC UNIT	: A3s
DATE DRILLED	: 23 - 24 February 1979
DRILLING METHOD	: Rotary Wash
HOLE DIAMETER	: 4 7 8" (124mm)
WATER LEVEL	: Not encountered

LOG OF BORING LP-B-2
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 6-2

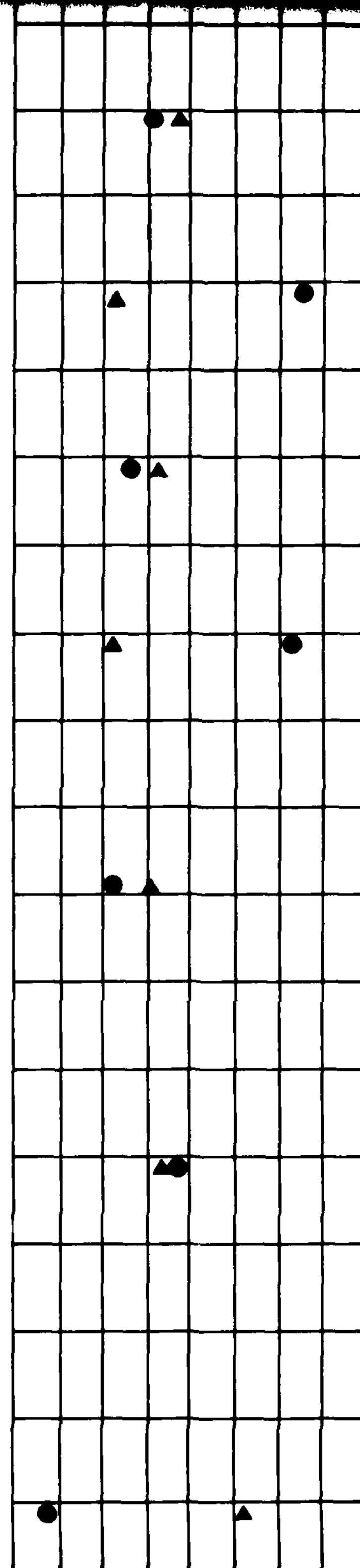
FUGRO NATIONAL, INC.

AFV-06

CHECKED BY________________________ APPROVED BY________________________

SAMPLE TYPE	% RECOVERY	N VALUE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	SOIL DESCRIPTION	REMARKS	▲(pcf) 80 90 100 110 120 130 140 / ●(%) 5 10 15 20 25 30 35	SIEVE ANALYSIS GR	SA	FI	LL	PI
	100		0	0		CL-ML	SANDY CLAY to SANDY SILT, yellow brown, stiff, slightly plastic, calcareous; moderately cemented; some fine to medium subangular sand							
	100									0	45	55		
	100					SM								
	100		3	10			GRAVELLY SAND, brown, fine to coarse, poorly graded, dense, angular to subrounded, calcareous; some fine to coarse subangular to subrounded gravel; little silt.			29	57	14		
	85					SP-SM								
	100		6	20			SAND, light brown, fine to medium, poorly graded, dense, subangular to subrounded, calcareous; occasional cemented lenses; trace silt; occasional lenses of silty clay			0	89	11		
	100					SM								
	100		9	30			SILTY SAND, light brown, fine to medium, poorly graded, medium dense to dense, subangular, calcareous; some silt.			0	87	13		
	100		12	40										
	100		15	50		SP	SAND, light brown, fine to medium, poorly graded, dense, subangular to subrounded, calcareous; occasional cemented lenses throughout; layer of highly plastic clay (64.0'-65.5') and (69.5'-74.5')			0	97	3		
	100		18	60										

Recovery	Elevation	Depth	Classification	Description					
100	-18	60		and (69.5'-74.5')					
			CH						
			SP						
100	-21	70	CH		0	3	97	79	58
100	-24	80	SP		0	96	4		
100	-27	90	CH	CLAY, red brown, very stiff, *highly plastic, calcareous*					
100	-30	100							
100	-33	110	SP-SM	SAND, light brown, fine, poorly graded, dense, subangular to subrounded, calcareous; occasional cemented lenses throughout; trace silt					
100	-36	120			0	88	12		
	-39	130							
100	-42	140	SM	SILTY SAND, brown, fine, poorly graded, dense to very dense, angular	0	64	36		



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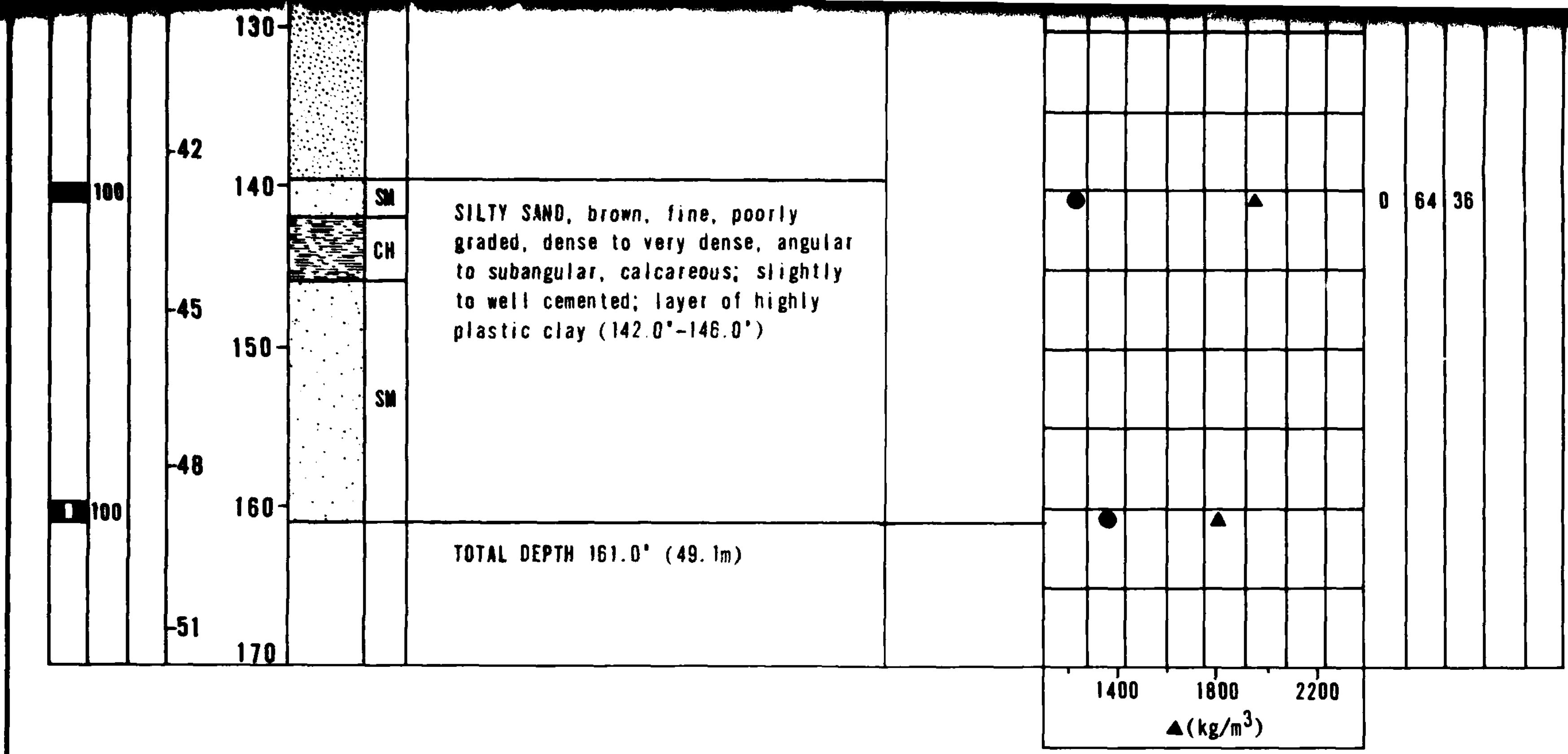


EXPLANATION

- FUGRO DRIVE SAMPLE
- BULK SAMPLE
- PITCHER TUBE SAMPLE
- STANDARD PENETRATION TEST SAMPLE
- CORE SAMPLE

N - STANDARD PENETRATION RESISTANCE

▲ - DRY UNIT WEIGHT (ASTM: D-2937-71)

● - MOISTURE CONTENT (ASTM: D-2216-71)

NR - NO RECOVERY

BORING DETAILS

ELEVATION	: 720' (219m)
SURFICIAL GEOLOGIC UNIT	: A5i
DATE DRILLED	: 24-25 February 1979
DRILLING METHOD	: Rotary Wash
HOLE DIAMETER	: 4 7/8" (124mm)
WATER LEVEL	: Not Encountered

LOG OF BORING LP-B-3
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE
B-3

FUGRO NATIONAL, INC.

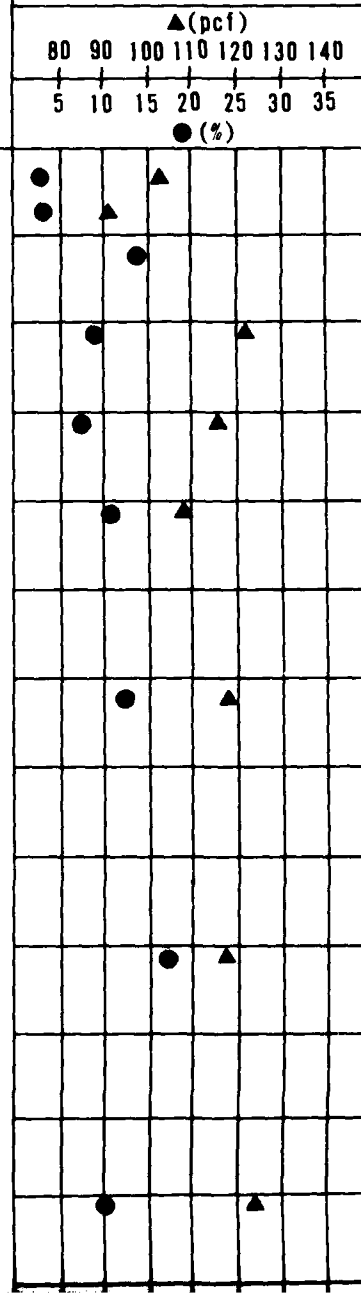
AFV-08

3

CHECKED BY ________ APPROVED BY ________

FN-TR-28-1

SAMPLE TYPE	% RECOVERY	N VALUE	DEPTH METERS	DEPTH FEET	USCS	SOIL DESCRIPTION	REMARKS
	100		0	0	SM	SILTY SAND, brown, fine to coarse, poorly graded, medium dense, angular, calcareous; some silt.	
	100				GC		
	100				GW-GC	SANDY GRAVEL, brown, fine to coarse, poorly to well graded, dense, angular, calcareous; some fine to coarse angular to subangular sand; trace to little clay; occasional cobbles to 6'' size.	
	100		3	10	GC		
	100				SP-SM		
	100		6	20	SC	GRAVELLY SAND, red-brown, fine to coarse, poorly graded, dense angular to subrounded, calcareous; some fine to coarse angular to subangular gravel; trace silt (14 5'–18 0'); little silty clay (18 0'–30 0')	
	100						
	100		9	30	GP-GM	SANDY GRAVEL, light brown, fine to coarse, poorly to well graded, dense to very dense, angular to subrounded, calcareous; some fine to coarse angular to subangular sand; trace silt; occasional lenses of gravelly sand throughout; occasional cobbles.	moderate to strong drill chatter
			12	40			
	100		15	50			
	100		18	60	GW-GM		



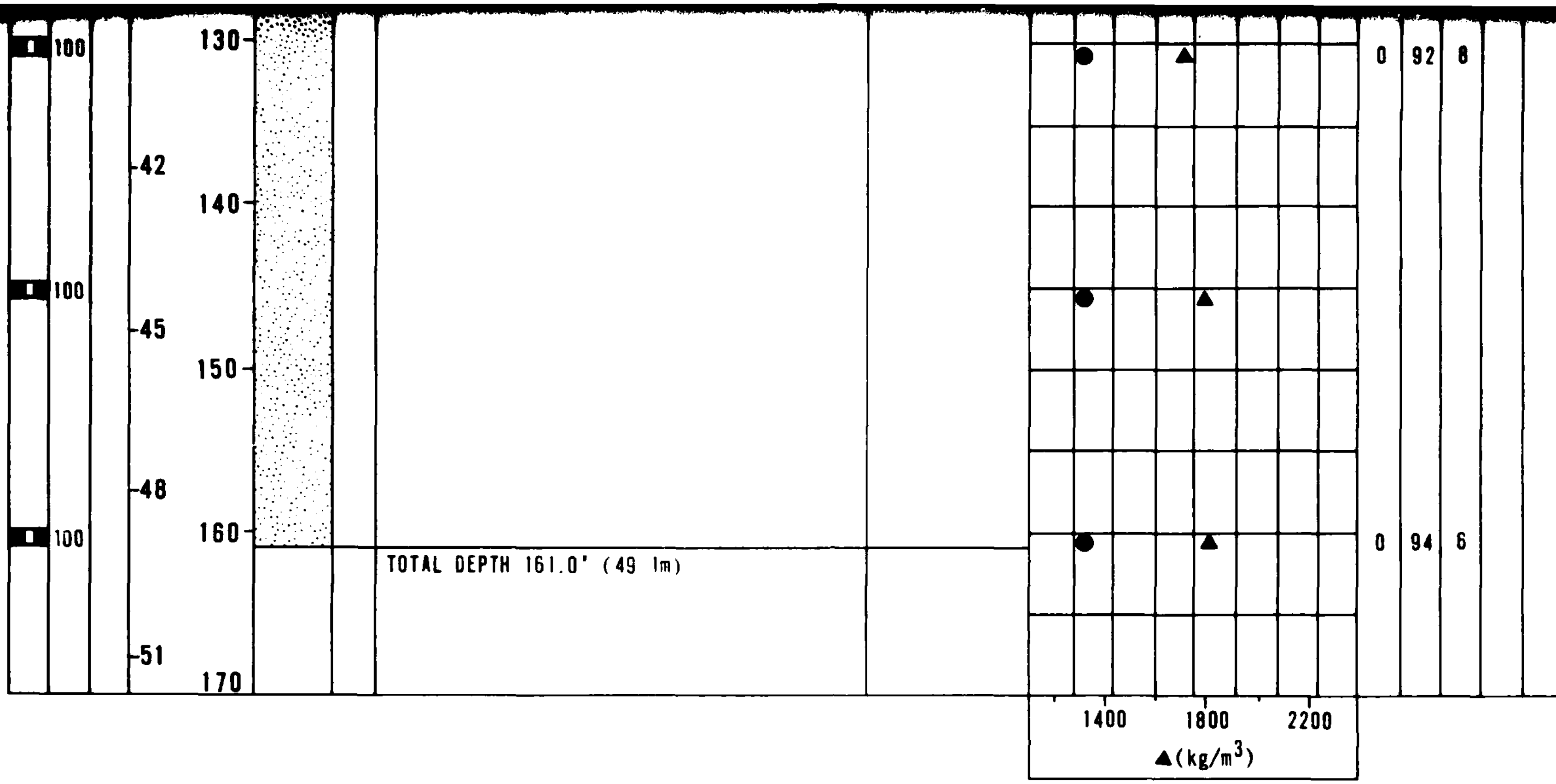
SIEVE ANALYSIS GR	SA	FI	LL	PI
38	35	27		
60	32	8		
40	51	9		
37	49	14	63	32
49	40	11		

10 AUG 79

100	-18	60	GW-GM		49	40	11
	-21	70					
100	-24	80	GP-GM				
100	-27	90		SAND yellow brown, fine to medium, poorly graded, dense to very dense, angular to rounded, calcareous; trace silt; occasional cemented lenses throughout.			
100	-30	100			0	91	9
	-33	110					
100	-36	120	SP-SM		2	91	7
100	-39	130			0	92	8
	-42						

1

2



EXPLANATION

- FUGRO DRIVE SAMPLE
- BULK SAMPLE
- PITCHER TUBE SAMPLE
- STANDARD PENETRATION TEST SAMPLE
- CORE SAMPLE
- N - STANDARD PENETRATION RESISTANCE
- ▲ - DRY UNIT WEIGHT (ASTM: D-2937-71)
- ● - MOISTURE CONTENT (ASTM: D-2216-71)
- NR - NO RECOVERY

BORING DETAILS

ELEVATION	: 1040' (317m)
SURFICIAL GEOLOGIC UNIT	: A5i
DATE DRILLED	: 25-26 February 1979
DRILLING METHOD	: Rotary Wash
HOLE DIAMETER	: 4 7/8" (124mm)
WATER LEVEL	: Not encountered

LOG OF BORING LP-B-4
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 6-4

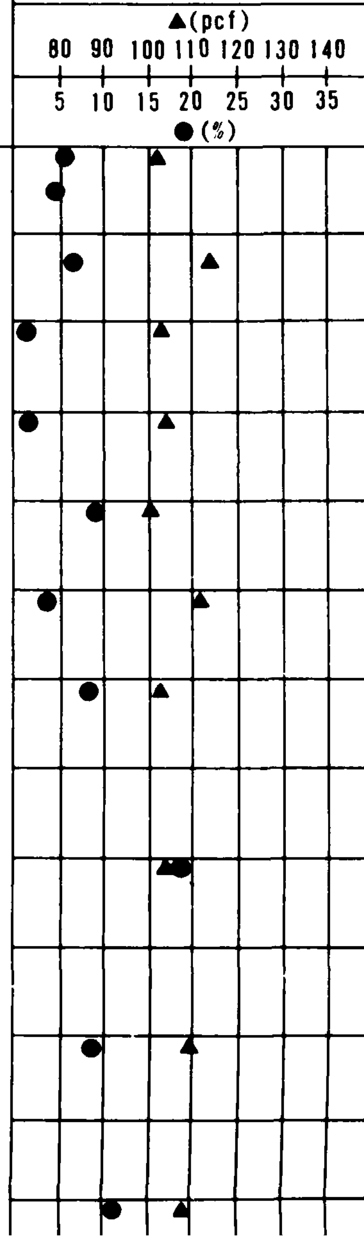
FUGRO NATIONAL, INC.

AFV-08

3

CHECKED BY________ APPROVED BY________

SAMPLE TYPE	% RECOVERY	N VALUE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
	100		0	0		SM	GRAVELLY SAND, light brown, fine to coarse, poorly graded, medium dense, subangular to subrounded, calcareous; some fine to coarse gravel; little silt.						
	80								35	47	18		
	100					SP-SM							
	100		3	10			SAND, light brown, fine to medium, poorly graded, dense to very dense, subangular to subrounded, calcareous; occasional cemented layers throughout; trace silt (6.0'-15.5'), (68.5'-73.0') and 158.5'-160.7'); some fine gravel (149.0'-160.7')		2	91	7		
	100					SP							
	100		6	20					0	97	3		
	100												
	100		9	30									
	100		12	40					0	97	3		
	100		15	50									
	100		18	60									



AD-A113 416 FUGRO NATIONAL INC LONG BEACH CA F/G 13/2
MX SITING INVESTIGATION. GEOTECHNICAL EVALUATION. VOLUME I. ARI--ETC(U)
NOV 79 F04704-78-C-0027
UNCLASSIFIED FN-TR-28-VOL-1 NL

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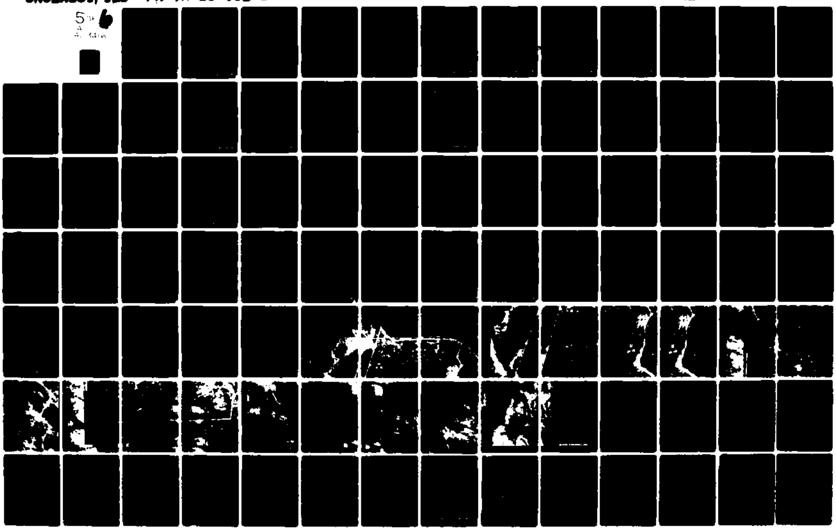

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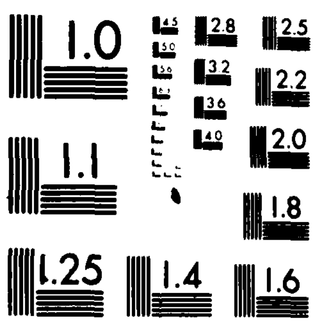
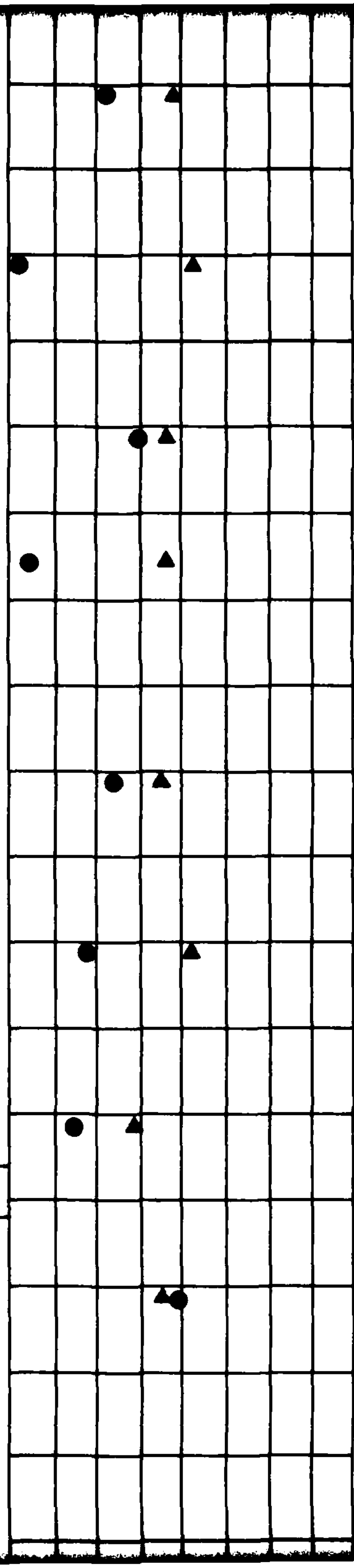
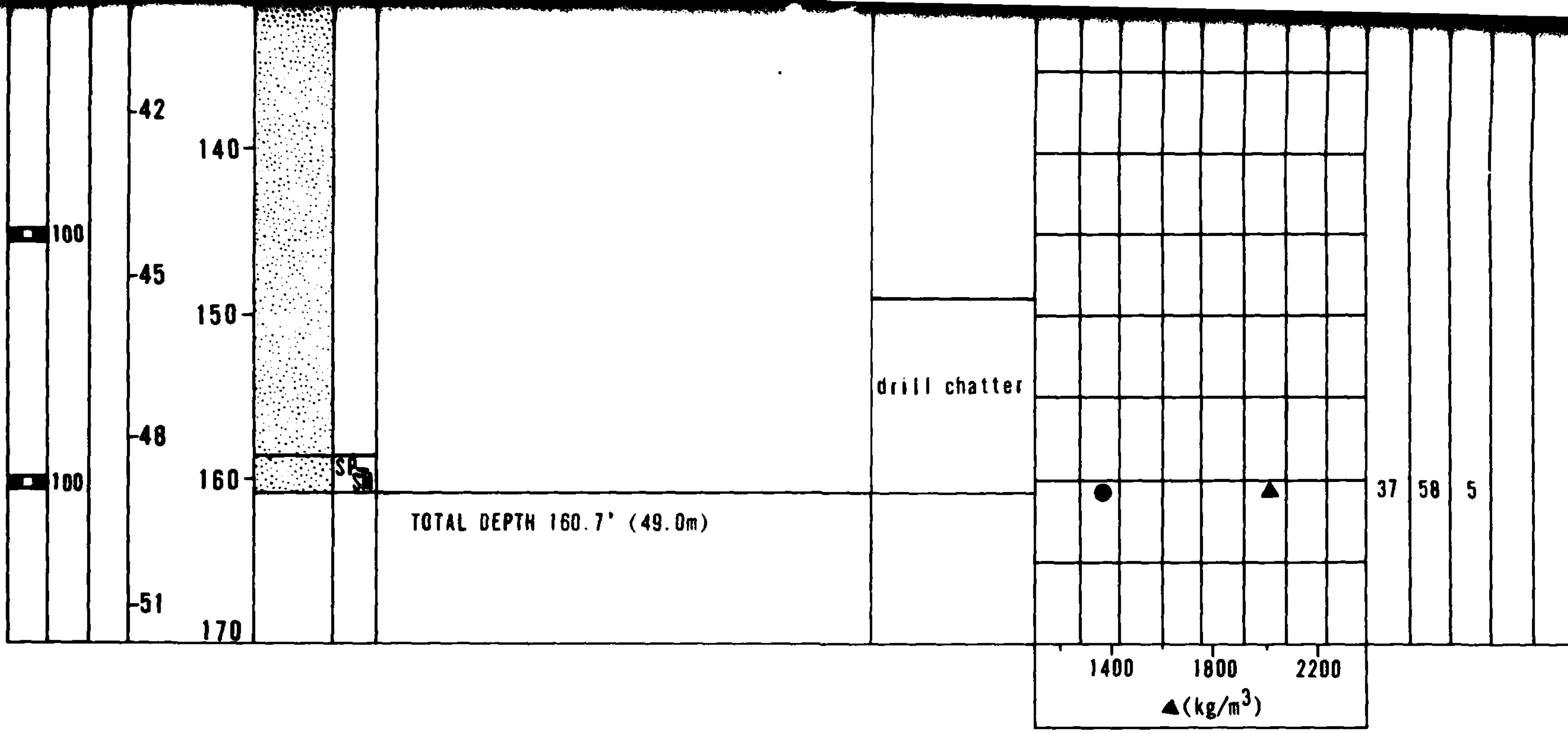


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

Recovery	Elevation	Depth	Soil	Remarks	Gradation
100	-18	60			
100	-21	70	SP-SM		0 95 5
100	-24	80	SP		
100	-27	90	SP		
100	-30	100	SP		0 96 4
100	-33	110	SP		
100	-36	120	SP	drill chatter	
100	-39	130	SP		0 97 3
	-42	140	SP		
100					



2



EXPLANATION

- FUGRO DRIVE SAMPLE
- BULK SAMPLE
- PITCHER TUBE SAMPLE
- STANDARD PENETRATION TEST SAMPLE
- CORE SAMPLE
- N – STANDARD PENETRATION RESISTANCE
- ▲ – DRY UNIT WEIGHT (ASTM: D-2937-71)
- ● – MOISTURE CONTENT (ASTM: D-2216-71)
- NR – NO RECOVERY

BORING DETAILS

ELEVATION	: 840' (256m)
SURFICIAL GEOLOGIC UNIT	: A2
DATE DRILLED	: 27-28 February 1979
DRILLING METHOD	: Rotary Wash
HOLE DIAMETER	: 4 7/8" (124mm)
WATER LEVEL	: Not Encountered

LOG OF BORING LP-B-5
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE B-5

FUGRO NATIONAL, INC.

AFV-86

3

SECTION 7.0

TRENCH AND TEST PIT LOGS

EXPLANATIONS OF TRENCH AND TEST PIT LOGS

See Section 6.0, "Boring Logs", for explanations.

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
sample	0	0		SP-SM	loose	SAND, yellow brown, fine, poorly graded, subangular to subrounded, slightly moist, calcareous; trace silt; some fine to coarse angular to subangular gravel (11.0'- 12.0'); stage II caliche (4.0'-7.0').	vertical walls stable	0	90	10		
	1, 2, 3	2, 4, 6, 8, 10			medium dense							
sample					dense			38	55	7		
	4	12			medium dense							
		14				TOTAL DEPTH 14.0' (4.3m)						
	5, 6	16, 18, 20										

TRENCH DETAILS

SURFACE ELEVATION : 800' (244m)
DATE EXCAVATED : 20 February 1979
SURFICIAL GEOLOGIC UNIT : A3d
TRENCH LENGTH : 16' (4.9m)
TRENCH ORIENTATION : E-W

LOG OF TRENCH LP-T-1
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 7-1

FUGRO NATIONAL, INC.

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
	0	0		SM	medium dense to dense	GRAVELLY SAND, yellow brown, fine to coarse, poorly graded, slightly moist, angular, calcareous; some fine to coarse gravel; some silt.	vertical walls stable	26	51	23		
	1	2–8				SILTY SAND, light brown, fine to coarse, poorly graded, slightly moist, angular, calcareous; some silt; stage III caliche (2.7'-3.5').						
	3–4	10–14		SP	dense to very dense	SAND, light brown, fine, poorly graded, dry, subangular to subrounded trace silt.	vertical walls caving slightly					
	5–6	14–20				TOTAL DEPTH 14.0' (4.3m)						

TRENCH DETAILS

SURFACE ELEVATION : 875' (267m)
DATE EXCAVATED : 21 February 1979
SURFICIAL GEOLOGIC UNIT : A5o
TRENCH LENGTH : 15' (4.6m)
TRENCH ORIENTATION : N-S

LOG OF TRENCH LP-T-2
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 7-2

FUGRO NATIONAL, INC.

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
	0–1.4	0–4.5		SM	medium dense to dense	GRAVELLY SAND: light brown, fine to coarse, poorly graded, dry, subangular, calcareous; some fine to coarse subrounded gravel, little silt; stage III caliche (1.0'–4.0').	vertical walls stable (0'–12.0')	37	44	19		
		4.5–6.5		SP-SM	medium dense to dense	SAND, gray-white, fine, poorly graded, dry, subrounded to rounded, trace silt.						
		6.5–11.0		GP	medium dense to dense	SANDY GRAVEL, brown, fine, poorly graded, dry, subrounded, calcareous; some subrounded sand; layer of silty sand (11.0'–12.0').						
		11.0–12.0		SM	very dense							
	3.7	12				TOTAL DEPTH 12.0' (3.7m)						

TRENCH DETAILS

SURFACE ELEVATION : 840' (256m)
DATE EXCAVATED : 22 February 1979
SURFICIAL GEOLOGIC UNIT : A2
TRENCH LENGTH : 12' (3.7m)
TRENCH ORIENTATION : NW-SE

LOG OF TRENCH LP-T-3
VERIFICATION SITE, LA POSA COP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 7-3

FUGRO NATIONAL, INC.

APPROVED BY ____ CHECKED BY ____

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
	0	0		GM-GC	medium dense	SANDY GRAVEL, light brown, fine to coarse, poorly graded, dry, subangular to subrounded, calcareous; some fine to coarse sand; trace to some slightly plastic silt; occasional cobbles to 8" size (0.0'-5.0'); stage II caliche (7.0'-8.0').	vertical walls stable	36	35	29	24	5
	1	2–4		GM			vertical walls caving slightly					
	2	6			dense		vertical walls stable					
		8				TOTAL DEPTH 8.0' (2.4m)	cementation at 8.0' exceeded capacity of Case 580C backhoe					
	3	10										
		12										
	4	14										
	5	16										
		18										
	6	20										

TRENCH DETAILS

SURFACE ELEVATION	: 765' (233m)
DATE EXCAVATED	: 24 February 1979
SURFICIAL GEOLOGIC UNIT	: A5i
TRENCH LENGTH	: 14' (4.3m)
TRENCH ORIENTATION	: NE-SW

LOG OF TRENCH LP-T-4
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 7-4

FUGRO NATIONAL, INC.

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SIEVE ANALYSIS SA	SIEVE ANALYSIS FI	LL	PI
	0 – 2	0 – 7.0		GW-GM	medium dense to dense	SANDY GRAVEL, brown, fine to coarse, poorly graded, slightly moist to dry, subangular, calcareous; some fine to coarse sand; trace silt; occasional cobbles to 6" size; stage I caliche (2.5'-7.0').	vertical walls stable	52	38	10		
						TOTAL DEPTH 7.0' (2.1m)	cementation at 7.0' exceeded capacity of Case 580C backhoe					

Depth scale: Meters 0, 1, 2, 3, 4, 5, 6; Feet 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20

TRENCH DETAILS

SURFACE ELEVATION : 1160' (354m)
DATE EXCAVATED : 26 February 1979
SURFICIAL GEOLOGIC UNIT : A1/A5y
TRENCH LENGTH : 12' (3.7m)
TRENCH ORIENTATION : NW-SE

LOG OF TRENCH LP-T-5
VERIFICATION SITE, LA POSA COP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 7-5

FUGRO NATIONAL, INC.

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
	0	0–1		SP-SM	loose	SAND, yellow brown, fine to medium, poorly graded, slightly moist, subangular to subrounded, calcareous; some fine angular gravel (2 5'-5 0'); trace silt.						
	1	1–5			medium dense			11	82	7		
		5				TOTAL DEPTH 5.0' (1.5m)						

SURFACE ELEVATION: 755' (230m)
SURFICIAL GEOLOGIC UNIT. A3s

LOG OF TEST PIT LP-P-1

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
	0	0–1		SP	loose	SAND, yellow brown, fine, poorly graded, slightly moist, subrounded.		0	98	2		
	1	1–5			medium dense							
		5				TOTAL DEPTH 5.0' (1.5m)						

SURFACE ELEVATION: 825' (251m)
SURFICIAL GEOLOGIC UNIT: A3d

LOG OF TEST PIT LP-P-2

LOGS OF TEST PITS LP-P-1 AND LP-P-2
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 7-6

FUGRO NATIONAL, INC.

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
	0	0		GP	medium dense to dense	SANDY GRAVEL, light brown, fine to coarse, poorly graded, moist, angular, calcareous; some fine to coarse angular sand.						
		1										
		2										
		3										
	1											
		4										
		5				TOTAL DEPTH 5.0' (1.5m)						

SURFACE ELEVATION: 840' (256m)
SURFICIAL GEOLOGIC UNIT: A1

LOG OF TEST PIT LP-P-3

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
	0	0		GP-GM	medium dense	SANDY GRAVEL, light brown, fine, poorly graded, slightly moist, angular to subangular, calcareous; some fine to coarse angular sand; trace silt; stage II caliche (4.0'-5.0').						
		1										
		2			dense							
		3										
	1											
		4										
		5				TOTAL DEPTH 5.0' (1.5m)						

SURFACE ELEVATION: 800' (244m)
SURFICIAL GEOLOGIC UNIT: A5o

LOG OF TEST PIT LP-P-4

LOGS OF TEST PITS LP-P-3 AND LP-P-4
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 7-7

FUGRO NATIONAL, INC.

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
	0–2.4	0–8		SM	loose (0–1); medium dense (1–4); dense (4–8)	SILTY SAND, light brown, fine, poorly graded, moist, subrounded, calcareous; some silt; stage II caliche (4.0'- 8.0').						
		8				TOTAL DEPTH 8.0' (2.4m)						

SURFACE ELEVATION: 880' (268m)
SURFICIAL GEOLOGIC UNIT: A3s

LOG OF TEST PIT LP-P-5

LOG OF TEST PIT LP-P-5
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 7-8

FUGRO NATIONAL, INC.

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
	0–1.5	0–5		SM	loose to medium dense (0–3'); dense (3–5')	SILTY SAND, yellow brown, fine, poorly graded, moist, subrounded calcareous; little silt; stage II caliche (3.0'- 4.0'); stage III caliche (4.0'-5.0').						
						TOTAL DEPTH 5.0' (1.5m)						

SURFACE ELEVATION: 905' (276m)
SURFICIAL GEOLOGIC UNIT: A3s

LOG OF TEST PIT LP-P-6

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
	0–1.5	0–5		SM	loose (0–1'); medium dense (1–4'); dense (4–5')	SILTY SAND, yellow brown, fine, poorly graded, moist, subrounded, calcareous; little silt; stage III caliche (4.0'-5.0').		0	83	17		
						TOTAL DEPTH 5.0' (1.5m)						

SURFACE ELEVATION: 900' (274m)
SURFICIAL GEOLOGIC UNIT: A3s

LOG OF TEST PIT LP-P-7

LOGS OF TEST PITS LP-P-6 AND LP-P-7
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 7-9

FUGRO NATIONAL, INC.

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
	0	0–5		SM	medium dense (0–3); dense (3–5)	SILTY SAND, light brown, fine to coarse, poorly graded, slightly moist, subangular, calcareous; some silt; trace fine angular to subangular gravel; stage III caliche (4.0'-5.0').						
		5				TOTAL DEPTH 5.0' (1.5m)						

SURFACE ELEVATION: 845' (258m)
SURFICIAL GEOLOGIC UNIT: A1/A3s

LOG OF TEST PIT LP-P-8

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
	0	0–3		SM	medium dense (0–2); dense (2–3)	SILTY SAND, light brown, fine to coarse, poorly graded, dry, subangular to subrounded, calcareous; some silt; little fine subrounded gravel; stage III caliche (1.0'-3.0').		20	49	31		
	1	3–5		GP-GM	dense	SANDY GRAVEL, light brown, fine to coarse, poorly graded, dry, subrounded to rounded, calcareous; some fine to coarse subrounded sand; trace silt.						
		5				TOTAL DEPTH 5.0' (1.5m)						

SURFACE ELEVATION: 825' (251m)
SURFICIAL GEOLOGIC UNIT: A2

LOG OF TEST PIT LP-P-9

LOGS OF TEST PITS LP-P-8 AND LP-P-9 VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 7-10

FUGRO NATIONAL, INC.

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
	0	0		SM	medium dense	SILTY SAND, light brown, fine to medium, poorly graded, slightly moist, subangular, calcareous; some silt; trace fine subrounded gravel (2.0'-5.0'); stage III caliche (2.0'-5.0').						
		1										
		2										
		3			dense							
	1											
		4										
		5				TOTAL DEPTH 5.0' (1.5m)						

SURFACE ELEVATION: 855' (261m)
SURFICIAL GEOLOGIC UNIT: A3s

LOG OF TEST PIT LP-P-10

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	GR	SA	FI	LL	PI
	0	0		SM	medium dense	SILTY SAND, light brown, fine to coarse, poorly graded, slightly moist, subangular to subrounded, calcareous; some nonplastic silt; stage II caliche (2.0'-4.0').		3	69	28	18	2
		1										
		2										
		3			dense							
	1											
		4		GM		SANDY GRAVEL, brown, fine, poorly graded, slightly moist, subangular to subrounded, calcareous; some subangular sand; little silt; stage II caliche (4.0'-5.0').						
		5				TOTAL DEPTH 5.0' (1.5m)						

SURFACE ELEVATION: 945' (288m)
SURFICIAL GEOLOGIC UNIT: A5i A3s

LOG OF TEST PIT LP-P-11

LOGS OF TEST PITS LP-P-10 AND LP-P-11
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 7-11

FUGRO NATIONAL, INC.

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BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
	0 – 1	0 – 5		SM	medium dense	SILTY SAND, light brown, fine to coarse, poorly graded, slightly moist, angular to subrounded, calcareous; some silt						
		5				TOTAL DEPTH 5.0' (1.5m)						

SURFACE ELEVATION: 1055' (322m)
SURFICIAL GEOLOGIC UNIT: A5i/A3s

LOG OF TEST PIT LP-P-12

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	GR	SA	FI	LL	PI
	0	0 – 3		SM	medium dense (0–2); dense (2–3)	SILTY SAND, light brown, fine to coarse, poorly graded, slightly moist, angular to subangular, calcareous; some silt; trace fine gravel.						
	1	3 – 5		GP-GM	dense	SANDY GRAVEL, brown, fine to coarse, poorly graded, dry, angular to subangular, calcareous; some fine to coarse angular sand; trace silt; stage II caliche (3.0'-5.0').						
		5				TOTAL DEPTH 5.0' (1.5m)						

SURFACE ELEVATION: 1100' (335m)
SURFICIAL GEOLOGIC UNIT: A5i

LOG OF TEST PIT LP-P-13

LOGS OF TEST PITS LP-P-12 AND LP-P-13
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 7-12

FUGRO NATIONAL, INC.

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SIEVE ANALYSIS SA	SIEVE ANALYSIS FI	LL	PI
0–2 ft	0	0				GRAVELLY SAND, gray, fine to coarse, poorly graded, slightly moist, subangular, calcareous; some fine to coarse subangular to subrounded gravel.						
		1			medium dense			46	53	1		
		2										
	1	3			dense							
		4		SP								
		5										
	2	6										
		7										
		8				TOTAL DEPTH 8.0' (2.4m)						
		9										
	3	10										

SURFACE ELEVATION: 725' (221m)
SURFICIAL GEOLOGIC UNIT: A1

LOG OF TEST PIT LP-P-14

LOG OF TEST PIT LP-P-14
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 7-13

FUGRO NATIONAL, INC.

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
	0	0		CL-ML	stiff (0'–1.5'); very stiff (1.5'–5.0')	SANDY CLAY to SANDY SILT, brown, dry, slightly plastic, calcareous; some fine to medium sand; stage I caliche (1.5'-5.0').		1	42	57	21	7
	1 (3.3')	1, 2, 3, 4, 5				TOTAL DEPTH 5.0' (1.5m)						

SURFACE ELEVATION: 720' (219m)
SURFICIAL GEOLOGIC UNIT: A5i

LOG OF TEST PIT LP-P-15

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	GR	SA	FI	LL	PI
	0	0–1		SP-SM	medium dense	GRAVELLY SAND, brown, fine to coarse, poorly graded, dry, subangular, calcareous; some fine subrounded gravel; trace silt.						
	1 (3.3')	1–5		GP-GM	dense	SANDY GRAVEL, brown, fine to coarse, poorly graded, dry, subrounded to subangular, calcareous; some fine to coarse subangular sand; trace silt.						
		5				TOTAL DEPTH 5.0' (1.5m)						

SURFACE ELEVATION: 600' (183m)
SURFICIAL GEOLOGIC UNIT: A5i

LOG OF TEST PIT LP-P-16

LOGS OF TEST PITS LP-P-15 AND LP-P-16
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 7-14

FUGRO NATIONAL, INC.

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
	0	0–1.7		SM	medium dense	SILTY SAND, light brown, fine to coarse, poorly graded, dry, subangular, calcareous; some silt; little fine subangular to subrounded gravel						
	1	1.7–5		GP-GM	dense to very dense	SANDY GRAVEL, light brown, fine to coarse, poorly graded, dry, subangular to subrounded, ca'careous; some fine to coarse, subangular to subrounded sand; occasional cobbles to 6" size; stage III caliche (1.7'-3.0').						
		5				TOTAL DEPTH 5.0' (1.5m)						

SURFACE ELEVATION: 830' (253m)
SURFICIAL GEOLOGIC UNIT: A5i

LOG OF TEST PIT LP-P-17

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
	0	0–0.8		SM	medium dense	GRAVELLY SAND, brown, fine to coarse, poorly graded, slightly moist, subangular, calcareous; some fine subrounded gravel; little silt.						
	1	0.8–5		GP-GM	dense to very dense	SANDY GRAVEL, light brown, fine to coarse, poorly graded, dry, subrounded, calcareous; some fine to coarse subrounded sand; trace silt; occasional cobbles to 8" size, stage II caliche (0.8'-5.0').						
		5				TOTAL DEPTH 5.0 (1.5m)						

SURFACE ELEVATION: 860' (262m)
SURFICIAL GEOLOGIC UNIT: A1

LOG OF TEST PIT LP-P-18

LOGS OF TEST PITS LP-P-17 AND LP-P-18
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 7-15

FUGRO NATIONAL, INC.

CHECKED BY ____ APPROVED BY ____

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	GR	SA	FI	LL	PI
	0	0–3		GC	medium dense / dense	SANDY GRAVEL, brown, fine to coarse, poorly graded, slightly moist, subangular, calcareous; some fine to coarse, subangular sand; some slightly plastic clay; occasional cobbles to 10" size; stage II caliche (1.0'-3.0').		43	33	24	30	11
	1	3–5		GP-GM	dense	SANDY GRAVEL, light brown, fine to coarse, poorly graded, dry, subangular, calcareous; some fine to coarse subangular sand; trace silt; occasional cobbles to 10" size; stage II (3.0'-5.0').						
		5				TOTAL DEPTH 5.0' (1.5m)						

SURFACE ELEVATION: 990' (302m)
SURFICIAL GEOLOGIC UNIT: A5i

LOG OF TEST PIT LP-P-19

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	GR	SA	FI	LL	PI
	0–1	0–5		CL	stiff / hard	SANDY CLAY, light brown, dry, slightly plastic, calcareous; some fine to coarse angular sand; little fine angular gravel; stage III caliche (0.5'-3.5').						
		5				TOTAL DEPTH 5.0' (1.5m)						

SURFACE ELEVATION: 1145' (349m)
SURFICIAL GEOLOGIC UNIT: A5i

LOG OF TEST PIT LP-P-20

LOGS OF TEST PITS LP-P-19 AND LP-P-20
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 7-16

FUGRO NATIONAL, INC.

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
	0	0		SP	dense	GRAVELLY SAND, brown, fine to coarse, poorly graded, slightly moist, subangular, calcareous; some fine to coarse subangular gravel.	vertical walls caving slightly	41	57	2		
		5				TOTAL DEPTH 5.0' (1.5m)						

SURFACE ELEVATION: 930' (283m)
SURFICIAL GEOLOGIC UNIT: A5y/A1

LOG OF TEST PIT LP-P-21

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	GR	SA	FI	LL	PI
	0	0		GP-GM	medium dense (0-3'); dense (3-5')	SANDY GRAVEL, light brown, fine to coarse, poorly graded, dry, subangular, calcareous; some fine to coarse angular to subangular sand; trace silt; stage I caliche (2.5'-5.0'); occasional cobbles to 5'' size.						
		5				TOTAL DEPTH 5.0' (1.5m)						

SURFACE ELEVATION: 1003' (306m)
SURFICIAL GEOLOGIC UNIT: A5I

LOG OF TEST PIT LP-P-22

LOGS OF TEST PITS LP-P-21 AND LP-P-22
VERIFICATION SITE, LA POSA COP, ARIZONA

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FIGURE 7-17

FUGRO NATIONAL, INC.

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
	0	0		GP-GM	dense	SANDY GRAVEL, light brown, fine to coarse, poorly graded, dry, angular to subangular, calcareous; little fine to coarse angular sand; trace silt; occasional cobbles to 8" size; stage III caliche (0.5'-5.0').						
		1										
		2										
		3										
	1											
		4										
		5				TOTAL DEPTH 5.0' (1.5m)						

SURFACE ELEVATION: 1240' (378m)
SURFICIAL GEOLOGIC UNIT: A5i

LOG OF TEST PIT LP-P-23

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
	0	0		SM	dense	GRAVELLY SAND, light brown, fine to coarse, poorly graded, slightly moist, subangular, calcareous; some fine to coarse angular gravel; some silt; stage II caliche (0.5'-3.5').						
		1						33	42	25		
		2										
		3										
	1											
		4										
		5				TOTAL DEPTH 5.0' (1.5m)						

SURFACE ELEVATION: 1035' (315m)
SURFICIAL GEOLOGIC UNIT: A5i

LOG OF TEST PIT LP-P-24

APPROVED BY ____

CHECKED BY ____

LOGS OF TEST PITS LP-P-23 AND LP-P-24
VERIFICATION SITE, LA POSA CDP, ARIZONA

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DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 7-18

FUGRO NATIONAL, INC.

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
	0	0		ML	stiff (0–1')	SANDY SILT, light brown, slightly moist, slightly plastic, calcareous; some fine to coarse angular sand; trace fine angular gravel; occasional cobbles to 4" size (1.5'-5.0'); stage I caliche (1.0'-5.0').						
	1	1–5			very stiff (1'–5')							
						TOTAL DEPTH 5.0' (1.5m)						

SURFACE ELEVATION: 1145' (349m)
SURFICIAL GEOLOGIC UNIT: A5i

LOG OF TEST PIT LP-P-25

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	GR	SA	FI	LL	PI
	0	0		SM	medium dense (0–2')	GRAVELLY SAND, light brown, fine to coarse, poorly graded, slightly moist, angular, calcareous; some fine to coarse angular gravel; some silt (0 -3.0'); little silt (3.0'-5.0'); stage I caliche (3.0'-5.0').						
	1	2–5			dense (2'–5')							
						TOTAL DEPTH 5.0' (1.5m)						

SURFACE ELEVATION: 1025' (312m)
SURFICIAL GEOLOGIC UNIT: A5y

LOG OF TEST PIT LP-P-26

LOGS OF TEST PITS LP-P-25 AND LP-P-26 VERIFICATION SITE, LA POSA CDP, ARIZONA

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DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 7-19

FUGRO NATIONAL, INC.

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CHECKED BY

BULK SAMPLE	DEPTH (METERS)	DEPTH (FEET)	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
	0	0–5		GP-GM	medium dense (0'–1.0'); dense (1.0'–5.0')	SANDY GRAVEL, light brown, fine to coarse, poorly graded, dry, subangular, calcareous; some fine to coarse, angular sand; trace silt; occasional cobbles to 4" size; stage I caliche (1.0'–4.0').		63	27	10		
						TOTAL DEPTH 5.0' (1.5m)						

SURFACE ELEVATION: 1120' (341m)
SURFICIAL GEOLOGIC UNIT: A5i

LOG OF TEST PIT LP-P-27

BULK SAMPLE	DEPTH (METERS)	DEPTH (FEET)	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI	LL	PI
	0	0–1.5		GM	medium dense (0'–1.0'); very dense (1.0'–5.0')	SILTY GRAVEL, light brown, fine to coarse, poorly graded, slightly moist, angular, calcareous; some silt; some fine to coarse subangular sand; stage III caliche (1.0'–1.5').		46	25	29	30	3
		1.5–5		GM		SANDY GRAVEL, light brown, fine to coarse, poorly graded, dry, subangular, calcareous; little fine to coarse subangular sand; little silt; stage III caliche (1.5'–5.0').						
						TOTAL DEPTH 5.0' (1.5m)						

SURFACE ELEVATION: 1060' (323m)
SURFICIAL GEOLOGIC UNIT: A5i

LOG OF TEST PIT LP-P-28

LOGS OF TEST PITS LP-P-27 AND LP-P-28
VERIFICATION SITE, LA POSA CDP, ARIZONA

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DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 7-20

FUGRO NATIONAL, INC.

SECTION 8.0

SURFICIAL SAMPLE LOGS

EXPLANATIONS OF SURFICIAL SAMPLE LOGS

Finalized logs of the surficial samples are presented in this section. The explanations provided here are to serve as general guidelines to reading the logs.

A. Designations - Surficial samples are identified as follows:

LA-CS-1
LA - abbreviation for the site (e.g., LA - La Posa)
CS - abbreviation for surficial sample
1 - number of activity

B. Ground Surface Elevation - Indicated elevations on the logs are estimated from topographic maps of the study area within an accuracy of half the contour interval.

C. Surficial Geologic Unit - Indicates the surficial geologic unit in which the activity is located.

D. Depth - Indicates depth interval for which soil description is given.

E. USCS - Unified Soil Classification Symbol; see Table 6-1 of Section 6.0, "Boring Logs", for details of USCS.

F. Soil Description - Soil is described based on field visual descriptions and/or laboratory test results. See Section 6.0, "Boring Logs", for procedures of soil description.

G. Sieve Analysis, LL and PI - These are from results of laboratory tests. See Section 6.0, "Boring Logs", for explanation.

ACTIVITY NUMBER	GROUND SURFACE ELEVATION, FEET (METERS)	SURFICIAL GEOLOGIC UNIT	DEPTH, FEET (METERS)	USCS	SOIL DESCRIPTION	SIEVE ANALYSIS				
						GR	SA	FI	LL	PI
LP-CS-1	785 (239)	A3d	0.0-2.0 (0.0-0.61)	SM	SILTY SAND, yellow brown, fine to medium, poorly graded, loose, slightly moist, subangular to subrounded; calcareous; little silt	0	86	14		
LP-CS-3	800 (244)	A3s	0.0-2.0 (0.0-0.61)	SP-SM	SAND, light yellow brown, fine to medium, poorly graded, loose, slightly moist, subangular to subrounded, calcareous; trace silt.					
LP-CS-6	865 (264)	A3s	0.0-2.0 (0.0-0.61)	SM	SILTY SAND, light yellow brown, fine to medium, poorly graded, loose, slightly moist, subangular to subrounded, calcareous; little silt					
LP-CS-8	855 (261)	A5i	0.0-2.0 (0.0-0.61)	SM	SILTY SAND, light brown, fine to coarse, poorly graded, medium dense, slightly moist, angular, calcareous; some silt; trace fine angular gravel					
LP-CS-10	770 (235)	A3s	0.0-2.0 (0.0-0.61)	SM	SILTY SAND, light brown, fine to medium, poorly graded, loose, slightly moist, subangular to subrounded, calcareous; little silt; trace fine angular gravel					
LP-CS-12	820 (250)	A5i	0.0-2.0 (0.0-0.61)	GM	SANDY GRAVEL, light yellow brown, fine, poorly graded, dense, slightly moist, angular to subangular, calcareous; some fine to coarse angular to subangular sand; little silt; stage III caliche (1.5'-2.0')					
LP-CS-14	875 (267)	A5i A3s	0.0-2.0 (0.0-0.61)	SC-SM	CLAYEY SAND to SILTY SAND, light brown, fine to coarse, poorly graded, medium dense, slightly moist, subangular, calcareous; some slightly plastic silty clay to clayey silt; little fine subangular gravel; stage II caliche (1.5'-2.0').	14	55	31	19	4
LP-CS-16	820 (250)	A1 A3s	0.0-2.0 (0.0-0.61)	SM	SILTY SAND, light brown, fine, poorly graded, loose, slightly moist, subangular to subrounded, calcareous; some silt.					
LP-CS-19	840 (256)	A1 A3s	0.0-2.0 (0.0-0.61)	SM	SILTY SAND, light brown, fine, poorly graded, medium dense, slightly moist, subangular, calcareous; some silt.					

LOGS OF SURFICIAL SOIL SAMPLES
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE B-1
1 OF 4

FUGRO NATIONAL, INC.

ACTIVITY NUMBER	GROUND SURFACE ELEVATION, FEET (METERS)	SURFICIAL GEOLOGIC UNIT	DEPTH, FEET (METERS)	USCS	SOIL DESCRIPTION	SIEVE ANALYSIS GR	SA	FI	LL	PI
LP CS 21	870 (265)	A3s	0 0 2 0 (0 0 0 61)	SM	SILTY SAND, brown, fine to medium poorly graded, medium dense, slightly moist, subangular, calcareous; little silt; trace fine subangular gravel.	6	75	19		
LP-CS-22	895 (273)	A3s	0 0-2.0 (0.0-0.61)	SM	SILTY SAND, light yellow brown, fine, poorly graded, loose, moist, subangular to subrounded, calcareous; some silt.					
LP-CS-24	910 (277)	A3s	0.0-2.0 (0.0-0.61)	SM	SILTY SAND, light yellow brown, fine, poorly graded, loose, moist, subangular to subrounded, calcareous; some silt.					
LP-CS-26	910 (277)	A5i A3s	0 0-2 0 (0 0-0.61)	SM	SILTY SAND, light brown, fine to medium, poorly graded, medium dense, slightly moist, subangular, calcareous; little silt; trace fine subangular gravel.					
LP-CS-28	975 (297)	A5i/A3s	0.0-2.0 (0.0-0.61)	SM	SILTY SAND, light brown, fine to medium, poorly graded, medium dense, slightly moist, subangular, calcareous; some silt.					
LP-CS-29	1010 (308)	A5i/A3s	0.0-2.0 (0.0-0.61)	SP-SM	SAND, light brown, fine to medium, poorly graded, medium dense, slightly moist, subangular, calcareous; trace silt	3	89	9		
LP-CS-32	1180 (360)	A5i	0.0-2.0 (0.0-0.61)	GP-GM	SANDY GRAVEL, light brown, fine to coarse, poorly graded, medium dense, dry, angular, calcareous; some fine to coarse angular sand; trace silt; occasional cobbles to 5" size.	52	42	6		
LP-CS-35	885 (270)	A5i	0.0-2.0 (0.0-0.61)	GM	SANDY GRAVEL, light brown, fine, poorly graded, medium dense to dense, dry, subrounded, calcareous; some fine to coarse subangular sand; trace to little silt; stage II caliche (0 5'-2 0').					
LP-CS-36	945 (288)	A5i	0 0-2 0 (0 0 0 61)	GM	SANDY GRAVEL light brown, fine, poorly graded medium dense to dense, dry, subangular, calcareous, some fine to coarse subangular sand; trace to little silt.					

LOGS OF SURFICIAL SOIL SAMPLES
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 8-1
2 OF 4

FUGRO NATIONAL, INC.

ACTIVITY NUMBER	GROUND SURFACE ELEVATION FEET (METERS)	SURFICIAL GEOLOGIC UNIT	DEPTH, FEET (METERS)	USCS	SOIL DESCRIPTION	SIEVE ANALYSIS GR	SA	FI	LL	PI
LP-CS-38	1040 (317)	A5i	0.0-2.0 (0.0-0.61)	CL	SANDY CLAY, brown, stiff, dry, slightly plastic, calcareous; some fine to coarse subangular sand; little fine subangular gravel; occasional cobbles to 5" size, stage II caliche (0.1'-2.0').	15	30	55	33	11
LP-CS-39	1090 (332)	A5i	0.0-2.0 (0.0-0.61)	ML	SANDY SILT light brown, stiff, dry, nonplastic, calcareous; some fine to coarse subangular sand; some fine to coarse subangular gravel; stage II caliche (1.0'-2.0').					
LP-CS-44	680 (207)	A5i	0.0-2.0 (0.0-0.61)	ML	SANDY SILT, brown, firm, dry, slightly plastic, calcareous; some fine to coarse subangular sand; stage I caliche (0.5'-2.0').					
LP-CS-45	660 (201)	A5i	0.0-2.0 (0.0-0.61)	ML	SANDY SILT, brown, firm, slightly moist, slightly plastic, calcareous; some fine to coarse subangular sand; trace fine subangular gravel; stage I caliche (1.75'-2.0').					
LP-CS-47	810 (247)	A5i	0.0-2.0 (0.0-0.61)	SM	GRAVELLY SAND, light brown, fine to coarse, poorly graded, dense, dry, subangular, calcareous; some fine to coarse angular to subangular gravel; some slightly plastic silt; stage II caliche (0.5'-2.0').	32	37	31	33	9
LP-CS-49	965 (294)	A5i/A1	0.0-2.0 (0.0-0.61)	GP-GM	SANDY GRAVEL, brown, fine to coarse, poorly graded, dense, slightly moist, subangular, calcareous; some fine to coarse subangular sand; trace silt.					
LP-CS-51	1040 (317)	A5i	0.0-2.0 (0.0-0.61)	SM	GRAVELLY SAND, brown, fine to coarse, poorly graded, medium dense, dry, subangular; calcareous; some fine to coarse subangular to subrounded gravel; little silt.					
LP-CS-55	1340 (408)	A5i	0.0-2.0 (0.0-0.61)	GM	SANDY GRAVEL, light brown, fine to coarse, poorly graded, dense, dry, angular to subangular, calcareous; some fine to coarse angular sand; little silt, occasional cobbles to 8" size; stage III caliche (0.25'-2.0').					

LOGS OF SURFICIAL SOIL SAMPLES
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 8-1
3 OF 4

FUGRO NATIONAL, INC.

ACTIVITY NUMBER	GROUND SURFACE ELEVATION, FEET (METERS)	SURFICIAL GEOLOGIC UNIT	DEPTH, FEET (METERS)	USCS	SOIL DESCRIPTION	SIEVE ANALYSIS GR	SA	FI	LL	PI
LP CS 57	1090 (332)	A5i	0.0 1 0 (0 0 0 30)	GM	SANDY GRAVEL, light brown, fine to coarse, poorly graded, medium dense, slightly moist, subangular, calcareous; some fine to coarse angular sand; trace to some silt	36	34	30		
			1.0-2.0 (0.30-0.61)	GP-GM						
LP-CS-59	1030 (314)	A5i	0.0-1.0 (0.0-0.30)	SM	SILTY SAND, light brown, fine to coarse, poorly graded, medium dense, dry, subangular, calcareous; some silt; some fine subrounded gravel.					
			1.0-2.0 (0.30-0.61)	GP-GM	SANDY GRAVEL, white brown, fine, poorly graded, dense, dry, subangular, calcareous; some fine to coarse subangular sand; trace silt; stage II caliche (1.0'-2.0').					
LP-CS-60	1000 (305)	A5i	0.0-2.0 (0.0-0 61)	SM	SILTY SAND, light brown, fine to coarse, poorly graded, medium dense, slightly moist, subangular, calcareous; some silt; trace fine angular gravel.					
LP-CS-62	1060 (323)	A5i	0.0-1.5 (0.0-0.46)	SM	SILTY SAND, light brown, fine to coarse, poorly graded, medium dense, slightly moist, angular, calcareous; some silt; little fine to coarse angular gravel; stage II caliche (1.0-1.5')	15	53	32		
LP-CS-64	1165 (355)	A5i	0.0-2.0 (0.0-0.61)	GM	SANDY GRAVEL, white brown, fine to coarse, poorly graded, dense, dry, angular, calcareous; some fine to coarse angular sand; little silt; occasional cobbles to 5" size; stage III caliche (0.25'-2.0').					
LP-CS-65	1120 (341)	A5i	0.0-2.0 (0.0-0.61)	SP-SM	GRAVELLY SAND, light brown, fine to coarse, poorly graded, dense, dry, angular, calcareous; some fine to coarse angular gravel; trace silt; stage I caliche (0.25'-2.0').					
LP CS 66	1160 (354)	A5y	0.0-2.0 (0.0-0.61)	GP-GM	SANDY GRAVEL, brown, fine to coarse, poorly graded, medium dense, dry, subangular, calcareous; some fine to coarse subangular sand; trace silt.					

LOGS OF SURFICIAL SOIL SAMPLES
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 8-1
4 OF 4

FUGRO NATIONAL, INC.

SECTION 9.0

LABORATORY TEST RESULTS

EXPLANATIONS OF LABORATORY TEST RESULTS

Laboratory test results are presented in this section. Table 9-1 contains a summary of laboratory test results. This table contains results of sieve analysis; plasticity data; in-situ dry unit weight, moisture content, degree of saturation, and void ratio for drive and Pitcher samples; results of compaction tests; and specific gravity of solids. Other tests such as triaxial compression, unconfined compression, direct shear, consolidation, chemical, and California Bearing Ratio (CBR) are indicated on the table. Tables 9-2 through 9-6 and Figures 9-1 through 9-2 present results of triaxial compression, unconfined compression, direct shear, chemical, and CBR tests.

All tests were performed in general accordance with the American Society for Testing and Materials (ASTM) procedures. The following table presents the ASTM designations for the tests performed during the investigation.

Type of Test	ASTM Designations
Particle Size Analysis	D 422-63
Liquid Limit	D 423-66
Plastic Limit	D 424-59
Unit Weight	D 2937-71
Moisture Content	D 2216-71
Compaction	D 1557-70
Specific Gravity of Solids	D 854-58
Triaxial	D 2850-70
Unconfined Compression	D 2166-66
Direct Shear	D 3080-72
Consolidation	D 2435-70
Test for Alkalinity (pH)	D 1067-70
Water Soluble Sodium	D 1428-64
Water Soluble Chloride	D 512-67
Water Soluble Sulphate	D 516-68
Water Soluble Calcium	D 511-72
Calcium Carbonate	D 1126-67
California Bearing Ratio (CBR)	D 1883-73

Explanation for the tables and figures presented in this section are as follows.

A. Activity Number - Boring, trench, test pit, or surficial sample designation.

B. Sample Number - Prefix indicates the type of sample; explanation is at the bottom of the table.

C. Sample Interval - This is the depth range measured from ground surface over which the sample was obtained.

D. Percent Finer by Weight - Presents the results of laboratory particle size analysis (ASTM D 422-63) performed on representative soil samples at the depth indicated. The numbers represent the percent (by dry weight) of the total sample weight passing through each sieve size indicated.

E. Atterberg Limits (ASTM D 423-66 and D 424-59)

LL - Liquid Limit, the water content (as percent of soil dry weight) corresponding to the arbitrary limit between the liquid and plastic states of consistency of a soil (ASTM D 423-66).

PL - Plastic Limit, the water content corresponding to an arbitrary limit between the plastic and the semisolid state of consistency of a soil (ASTM D 424-59).

PI - Plasticity Index, numerical difference between the liquid limit (LL) and the plastic limit (PL) indicating the range of moisture content within which a soil-water mixture is plastic.

NP - Nonplastic.

F. USCS - Unified Soil Classification Symbols are given here; see Table 6.1 in Section 6.0, "Boring Logs", for complete details of USCS system.

G. In Situ - Presents results of tests on drive and Pitcher samples.

Dry Unit Weight - indicates dry unit weight of soil determined as per ASTM D 2937-71

Moisture Content - weight of water reported in percent of dry weight of soil sample (ASTM D 2216-71)

Saturation - the degree of saturation in a soil sample is defined as the ratio (in percent) of the volume of water to the volume of all voids in the soil

Void Ratio - the numerical ratio of the volume of voids to the volume of solids in a soil specimen

H. Compacted - Indicates results of laboratory maximum dry density and optimum moisture content test as per ASTM D 1557-70.

I. Specific Gravity of Solids (ASTM D 854-58) - Indicates the ratio of (1) the weight in air of a given volume of soil solids at a stated temperature, to (2) the weight in air of an equal volume of distilled water at a stated temperature.

J. Triaxial - The triaxial compression tests were performed in accordance with the procedures of ASTM D 2850-70. The following explanations and definitions apply.

Triaxial Compression Test - a cylindrical specimen of soil is surrounded by a fluid in a pressure chamber and subjected to an isotropic pressure. An additional compressive load is then applied, directed along the axis of the specimen called the axial load.

Consolidated-Drained (CD) Test - a triaxial compression test in which the soil was first consolidated under an all-around confining stress (test chamber pressure), and was then compressed (and hence sheared) by increasing the vertical stress. Drained indicates that excess pore water pressure generated by strains are permitted to dissipate by the free movement of pore water during consolidation and compression.

Consolidated-Undrained (CU) Test - a triaxial compression test in which essentially complete consolidation under the confining (chamber) pressure is followed by a shear test at constant water content.

Confining Pressure (σ_3) - the isotropic chamber pressure applied to the soil specimen during consolidation and compression.

Maximum Deviator Stress ($\sigma_1 - \sigma_3$) - the difference between the major and minor principal stresses in the specimen at failure. The major principal stress on the specimen is equal to the unit axial load plus the chamber pressure and the minor principal stress on the specimen is equal to the chamber pressure.

Strain Rate - axial strain, ε, at a given stress level is defined as the ratio of the change in length (ΔL) of the specimen to the original length of the specimen (L_o). The rate of strain was controlled during the test so that this ratio increased at equal increments for each minute of testing.

Back Pressure - pressure in excess of atmospheric applied to the pore water of a soil sample. Back pressure is usually applied to (1) increase saturation of the sample, or (2) simulate the actual in-situ pressure regime.

K. Unconfined Compression - Test procedures were as described in ASTM D 2166-66. Unconfined compressive strength is defined as the load per unit area at which an unconfined prismatic or cylindrical specimen of soil will fail in a simple compression test. In these methods, unconfined compressive strength is taken as the maximum load attained per unit area or the load per unit area at 20 percent axial strain, whichever occurred first during the performance of a test.

L. Direct Shear - The procedures of ASTM D 3080-72 were followed for direct shear testing. In this test, soil under an applied normal load is stressed to failure by moving one section of the soil container (shear box) relative to the

other section. Normal stress is the value of load per unit area acting perpendicular to the plane of shearing. Maximum shear strength is defined as the maximum resistance (ksf) of a soil to shearing (tangential) stresses.

M. Consolidation (ASTM D 2435-70) - A consolidation test is a test in which a cylindrical soil specimen is laterally confined in a ring and compressed between porous plates. The term "consolidation", as used here, indicates the gradual reduction in volume of the soil mass resulting from an increase in compressive stress (axial load per unit area).

N. Chemical - The chemical tests performed on soil samples included: pH; water soluble sodium, chloride, sulphate, calcium; and calcium carbonate content. pH is an index of the acidity or alkalinity of a soil in terms of the logarithm of the reciprocal of the hydrogen ion concentration. ASTM test procedure designations for these chemical tests are included in the table at the beginning of the "Explanation of Laboratory Test Results".

O. CBR - California Bearing Ratio (CBR) is the ratio (in percent) of the resistance to penetration developed by a subgrade soil to that developed by a standard crushed-rock base material. The procedures for conducting a CBR test were as outlined in ASTM D 1883-73. The materials tested for CBR were also analyzed for particle size distribution (ASTM D 422-63) and compaction characteristics (ASTM D 1557-70). The term "percentage of maximum density" indicates the ratio (as a percentage) of the compacted sample

dry unit weight to maximum dry density obtained in the laboratory from ASTM D 1557-70, "Moisture-Density Relations of Soils Using 10-pound (4.5 kg) Hammer and 18-inch (457 mm) Drop."

ACTIVITY NUMBER	SAMPLE NUMBER (a)	SAMPLE INTERVAL		PERCENT FINER BY WEIGHT									
				STANDARD SIEVE OPENING							U S STANDARD SI		
				BLDRS.	COBBLES		GRAVEL				SAND		
		FEET	METERS	24"	12"	6"	3"	1½"	3/4"	3/8"	4	10	40
LP-B-1	P-1	0-1.0	0.00-0.30										
	P-2	3.0-3.9	0.91-1.19										
	P-3	6.0-7.0	1.83-2.13						100	94	90	86	72
	P-4	12.0-12.9	3.66-3.93						100	96	93	90	80
	P-5	15.5-16.6	4.72-5.06										
	P-6	20.0-20.8	6.10-6.34									100	95
	P-7	25.0-25.1	7.62-7.65										
	P-8	30.6-31.3	9.33-9.54									100	97
	P-9	40.0-40.7	12.19-12.41										
	P-10	50.0-51.1	15.24-15.58						100	99	95	94	72
	P-11	60.0-60.6	18.29-18.47									100	91
	P-12	70.0-70.8	21.34-21.58										
	P-13	80.0-80.8	24.38-24.63										
	P-14	95.0-95.8	28.96-29.20										
	P-15	110.0-110.6	33.53-33.71									100	97
	P-16	125.0-125.9	38.10-38.37										
	P-17	140.6-141.2	42.85-43.04										
	D-18	160.0-161.0	48.77-49.07										
LP-B-2	P-1	0.0-0.3	0.00-0.09										
	P-2	3.8-4.7	1.16-1.43						100	98	98	98	93
	P-3	6.5-7.3	1.98-2.23										
	P-4	10.9-11.8	3.32-3.60										
	P-5	15.0-15.8	4.57-4.82								100	95	84
	P-6	20.0-20.3	6.10-6.19										
	D-7	25.2-25.9	7.68-7.89						100	99	97	95	79
	D-8	30.2-30.9	9.20-9.42										
	D-9	40.0-40.5	12.19-12.34										
	D-10	50.1-50.8	15.27-15.48							100	99	97	56
	D-11	59.2-59.9	18.04-18.26										
	D-12	70.2-70.9	21.40-21.61										
	D-13	80.2-80.9	24.44-24.66								100	99	61
	D-14	90.1-90.6	27.46-27.61										
	P-15	100.0-100.9	30.48-30.75										
	P-16	120.3-121.0	36.67-36.88										100
	P-17	140.0-140.9	42.67-42.95										
	D-18	160.2-160.9	48.83-49.04							100	99	99	79
LP-B-3	P-1	0.0-0.9	0.00-0.27										
	P-2	2.8-3.2	0.85-0.98								100	98	93
	D-3	6.2-6.9	1.89-2.10										
	D-4	10.2-10.9	3.11-3.32					100	97	84	71	54	34
	P-5	15.0-15.9	4.57-4.85										

NOTES:

(a) Sample types
- SS – Standard split spoon
- P – Pitcher
- D – Fugro Drive
- B,b – Bulk

(b) NP – Not Plastic

(c) USCS – Unified Soil Classification System

(d) * Indicates that test has been performed and results are included in this report

			SP-SM	108.2	1733
			SP-SM	100.0	1602
			SM	107.4	1721
			SP	107.3	1719
			SP	101.1	1620
			SP	101.5	1626
			SP	104.6	1676
			SP-SM	105.0	1682
			SP	111.7	1789
			SP	105.1	1684
			SP	103.8	1663
			SP	101.2	1621
			SP	97.6	1563
			SP	99.2	1589
			SP-SM	96.2	1541
			SP	103.3	1655
			SP	101.5	1626
			SP	101.2	1621
			SM	97.1	1556
			SM	102.8	1647
			SM	94.4	1512
			SM	98.9	1584
			SM	97.1	1556
			SM	103.2	1653
			SP	112.4	1801
			SP	110.9	1777
			SP	104.2	1669
			SP	113.9	1825
			SP	109.1	1748

ERG (b)		USCS (c)	IN-SITU					COMPACTED			SPECIFIC GRAVITY OF SOLIDS	TRIAXIAL (d)	UNCONFINED COMPRESSION	DIRECT SHEAR	CONSOLIDATION	CHEMICAL	CBR
			DRY UNIT WEIGHT		MOISTURE CONTENT (%)	SATURATION (%)	VOID RATIO	MAXIMUM DRY DENSITY		OPTIMUM MOISTURE (%)							
	PI		(pcf)	(kg/m^3)				(pcf)	(kg/m^3)								
		SP-SM	108.2	1733	2.1	10.2	0.56										
		SP-SM	100.0	1602	5.8	22.9	0.69							*		*	
		SM	107.4	1721	8.5	40.4	0.57										
		SP	107.3	1719	3.7	17.5	0.57										
		SP	101.1	1620	14.1	57.1	0.67									*	
		SP	101.5	1626	4.5	18.4	0.66										
		SP	104.6	1676	7.8	34.5	0.61							*			
		SP-SM	105.0	1682	4.1	18.3	0.60										
		SP	111.7	1789	11.4	60.6	0.51										
		SP	105.1	1684	18.3	81.9	0.60										
		SP	103.8	1663	3.3	14.3	0.62										
		SP	101.2	1621	23.7	96.3	0.66										
		SP	97.6	1563	19.3	71.8	0.73										
		SP	99.2	1589	22.5	87.0	0.70										
		SP-SM	96.2	1541	23.6	84.8	0.75										
		SP	103.3	1655	19.5	83.4	0.63										
		SP	101.5	1626	22.3	91.2	0.66										
		SP	101.2	1621	17.8	72.3	0.66										
		SM	97.1	1556	2.1	7.7	0.74										
		SM	102.8	1647	6.8	28.7	0.64										
		SM	94.4	1512	11.7	40.3	0.78										
		SM	98.9	1584	8.4	32.2	0.70									*	
		SM	97.1	1556	7.5	27.5	0.74										
		SM	103.2	1653	6.7	28.6	0.63										
		SP	112.4	1801	5.4	29.2	0.50										
		SP	110.9	1777	5.7	29.6	0.52										
		SP	104.2	1669	15.9	69.6	0.62										
		SP	113.9	1825	12.3	69.3	0.48										
		SP	109.1	1748	10.4	51.6	0.54										
		SP	110.8	1775	5.4	28.0	0.52										
		SP-SM	108.1	1732	8.1	39.2	0.56										
		SP	106.4	1705	11.1	51.4	0.58										
		SP	107.2	1717	16.2	76.5	0.57										
		SM	108.9	1745	17.0	83.9	0.55									*	
		SP	98.2	1573	21.4	80.7	0.72										
		SP-SM	113.9	1825	4.2	23.7	0.48										
		CL-ML	94.5	1514	7.9	27.2	0.78										
		CL-ML	96.1	1540	4.3	15.4	0.75									*	
		SM	125.1	2004	5.0	38.9	0.35										
		SM	127.2	2038	4.4	36.6	0.32										
		SP-SM	106.0	1698	8.8	40.3	0.59							*			

SUMMARY OF LABORATORY TEST RESULTS
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 9-1
1 OF 4

FUGRO NATIONAL, INC.

AFV-01

2 3

ACTIVITY NUMBER	SAMPLE NUMBER (a)	SAMPLE INTERVAL		PERCENT FINER BY WEIGHT									
				STANDARD SIEVE OPENING							U S STANDARD		
				BLDRS.	COBBLES		GRAVEL				SAND		
		FEET	METERS	24"	12"	6"	3"	1½"	3/4"	3/8"	4	10	40
	D-6	20.2-20.9	6.16-6.37								100	98	92
	P-7	25.0-25.9	7.62-7.89										
	P-8	30.0-31.1	9.14-9.48										100
	P-9	40.0-40.3	12.19-12.28										
	P-10	48.0-49.0	14.63-14.94									100	95
	P-11	60.8-61.6	18.53-18.78										
	P-12	71.1-72.0	21.67-21.95										100
	P-13	80.0-80.9	24.38-24.66									100	96
	P-14	90.8-91.6	27.68-27.92										
	P-15	104.0-104.4	31.70-31.82										
	P-16	120.2-121.0	36.58-36.88										100
	P-17	140.0-140.9	42.67-42.95									100	99
	D-18	160.2-160.9	48.83-49.04										
LP-B-4	D-1	1.2-1.9	0.37-0.58										
	D-2	3.1-3.7	0.94-1.13					100	87	75	62	50	39
	D-3	6.0-6.3	1.83-1.92				100	75	62	49	40	31	17
	D-4	10.0-10.4	3.05-3.17										
	D-5	15.2-15.9	4.63-4.85					100	90	84	60	35	18
	D-6	20.0-20.7	6.10-6.31						100	87	63	45	26
	D-8	30.5-30.9	9.30-9.42										
	D-9	45.0-45.3	13.72-13.81										
	D-10	60.0-60.7	18.29-18.50					100	74	60	51	40	22
	D-11	75.0-75.7	22.86-23.07										
	D-12	90.2-90.7	27.49-27.65										
	D-13	100.1-100.8									100	99	94
	D-14	115.2-115.9	35.11-35.33							100	98	94	86
	D-15	130.0-130.6	39.62-39.81									100	99
	D-16	145.2-145.9	44.26-44.47										
	D-17	160.2-160.9	48.83-49.04									100	94
LP-B-5	D-1	0.2-0.9	0.06-0.27										
	D-2	2.0-2.8	0.61-0.85					100	93	82	65	48	35
	D-3	6.2-6.9	1.89-2.10										
	D-4	10.2-10.9	3.11-3.32						100	99	98	97	91
	D-5	15.2-15.9	4.63-4.85										
	P-6	20.0-21.1	6.10-6.43									100	89
	D-7	25.2-25.9	7.68-7.89										
	P-8	30.0-31.1	9.14-9.48										
	P-9	40.0-40.9	12.19-12.47								100	93	77
	D-10	50.2-50.9	15.30-15.51										
	D-11	60.2-60.9	18.35-18.56										
	D-12	70.2-70.9	21.40-21.61								100	98	79

NOTES:

(a) Sample types
- SS – Standard split spoon
- P – Pitcher
- D – Fugro Drive
- B,b – Bulk

(b) NP – Not Plastic

(c) USCS – Unified Soil Classification System

(d) * Indicates that test has been performed and results are included in this report

CHECKED BY ____ APPROVED BY ____

98	92	35	11						SP-SM	108.9	1745	3.7	18.2	0.55				
									SM	95.0	1522	13.2	46.1	0.77				
	100	58	13						SM	101.8	1631	10.5	43.2	0.66				
									SM	102.7	1645	9.1	38.4	0.64				
100	95	22	3						SP	108.0	1730	8.4	40.5	0.56				
									SP	108.0	1730	16.6	80.0	0.56				
	100	98	97	79	30	79	21	58	CH	91.4	1464	33.3	100.0	0.84				
100	96	41	4						SP	101.8	1631	12.7	52.4	0.66				
									CH	91.0	1458	31.4	99.6	0.85				
									SP-SM	99.9	1600	11.1	43.7	0.69				
	100	63	12						SP-SM	103.0	1650	18.6	79.0	0.64				
100	99	79	36						SM	121.7	1950	3.5	24.6	0.38				
									SM	112.0	1794	8.8	47.1	0.50				
									SM	101.3	1623	3.1	12.6	0.66				
50	39	31	27						GC	91.3	1463	3.6	11.5	0.84				
31	17	10	8						GW-GC			14.2						
									GC	121.7	1950	9.2	64.6	0.38				
35	18	12	9						SP-SM	116.7	1870	7.9	48.1	0.44				
45	26	17	14			63	31	32	SC	109.7	1757	10.9	54.9	0.54				
									GP-GM	119.1	1908	11.8	76.8	0.41				
									GP-GM	118.0	1890	16.6	100.0	0.43				
40	22	14	11						GW-GM	123.0	1970	10.2	74.5	0.37				
									GP-GM	126.6	2028	9.5	77.5	0.33				
									SP-SM	117.7	1886	7.2	45.1	0.43				
99	94	33	9						SP-SM	108.8	1743	8.2	40.4	0.55				
94	86	22	7						SP-SM	115.4	1849	6.7	39.3	0.46				
100	99	22	8						SP-SM	109.1	1748	6.2	30.8	0.54				
									SP-SM	112.1	1796	6.3	33.8	0.50				
100	94	34	6						SP-SM	113.3	1815	6.5	36.0	0.49				
									SM	101.0	1618	5.4	21.8	0.67				
48	35	22	18						SM			4.9						
									SP-SM	113.7	1821	5.8	32.5	0.48				
97	91	30	7						SP-SM	104.1	1668	2.0	8.7	0.62				
									SP	105.4	1689	2.2	9.9	0.60				
100	89	7	3						SP	100.1	1604	9.1	36.0	0.68				
									SP	111.2	1781	3.5	18.3	0.52				
									SP	100.7	1613	7.8	31.3	0.67				
93	77	8	3						SP	102.8	1647	17.7	74.8	0.64				
									SP	109.8	1759	7.7	38.9	0.53				
									SP	108.9	1745	10.6	52.3	0.55				
98	79	9	5						SP-SM	112.0	1794	1.4	7.5	0.50				

ERG (b)		USCS (c)	IN-SITU					COMPACTED			SPECIFIC GRAVITY OF SOLIDS	TRIAXIAL (d)	UNCONFINED COMPRESSION	DIRECT SHEAR	CONSOLIDATION	CHEMICAL	CBR
			DRY UNIT WEIGHT		MOISTURE CONTENT (%)	SATURATION (%)	VOID RATIO	MAXIMUM DRY DENSITY		OPTIMUM MOISTURE (%)							
	PI		(pcf)	(kg/m³)				(pcf)	(kg/m³)								
		SP-SM	108.9	1745	3.7	18.2	0.55										
		SM	95.0	1522	13.2	46.1	0.77										
		SM	101.8	1631	10.5	43.2	0.66										
		SM	102.7	1645	9.1	38.4	0.64										
		SP	108.0	1730	8.4	40.5	0.56										
		SP	108.0	1730	16.6	80.0	0.56							*			
	58	CH	91.4	1464	33.3	100.0	0.84									*	
		SP	101.8	1631	12.7	52.4	0.66										
		CH	91.0	1458	31.4	99.6	0.85						*				
		SP-SM	99.9	1600	11.1	43.7	0.69										
		SP-SM	103.0	1650	18.6	79.0	0.64										
		SM	121.7	1950	3.5	24.6	0.38										
		SM	112.0	1794	8.8	47.1	0.50										
		SM	101.3	1623	3.1	12.6	0.66										
		GC	91.3	1463	3.6	11.5	0.84										
		GW-GC			14.2												
		GC	121.7	1950	9.2	64.6	0.38										
		SP-SM	116.7	1870	7.9	48.1	0.44										
	32	SC	109.7	1757	10.9	54.9	0.54										
		GP-GM	119.1	1908	11.8	76.8	0.41										
		GP-GM	118.0	1890	16.6	100.0	0.43										
		GW-GM	123.0	1970	10.2	74.5	0.37										
		GP-GM	126.6	2028	9.5	77.5	0.33										
		SP-SM	117.7	1886	7.2	45.1	0.43										
		SP-SM	108.8	1743	8.2	40.4	0.55										
		SP-SM	115.4	1849	6.7	39.3	0.46										
		SP-SM	109.1	1748	6.2	30.8	0.54										
		SP-SM	112.1	1796	6.3	33.8	0.50										
		SP-SM	113.3	1815	6.5	36.0	0.49										
		SM	101.0	1618	5.4	21.8	0.67										
		SM			4.9												
		SP-SM	113.7	1821	5.8	32.5	0.48							*			
		SP-SM	104.1	1668	2.0	8.7	0.62										
		SP	105.4	1689	2.2	9.9	0.60										
		SP	100.1	1604	9.1	36.0	0.68										
		SP	111.2	1781	3.5	18.3	0.52										
		SP	100.7	1613	7.8	31.3	0.67										
		SP	102.8	1647	17.7	74.8	0.64										
		SP	109.8	1759	7.7	38.9	0.53										
		SP	108.9	1745	10.6	52.3	0.55										
		SP-SM	112.0	1794	1.4	7.5	0.50										

SUMMARY OF LABORATORY TEST RESULTS
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 9-1
2 OF 4

FUGRO NATIONAL, INC.

AFV-01

ACTIVITY NUMBER	SAMPLE NUMBER (a)	SAMPLE INTERVAL FEET	SAMPLE INTERVAL METERS	PERCENT FINER BY WEIGHT — STANDARD SIEVE OPENING — BLDRS. 24"	COBBLES 12"	COBBLES 6"	GRAVEL 3"	GRAVEL 1½"	GRAVEL 3/4"	GRAVEL 3/8"	U S STANDARD SIE[VE] — SAND 4	SAND 10	SAND 40
LP-B-5	D-13	80.2-80.9	24.44-24.66										
	D-14	88.2-88.9	26.88-27.10										
	D-15	100.2-100.9	30.54-30.75								100	99	84
	D-16	110.2-110.9	33.59-33.80										
	D-17	120.2-120.7	36.64-36.79										
	D-18	130.3-130.8	39.72-39.87									100	94
	D-20	160.0-160.6	48.77-48.95						100	78	63	49	28
LP-B-6	D-1	0.2-0.9	0.06-0.27					100	95	83	67	56	42
	D-3	4.2-4.9	1.28-1.49						100	89	72	51	20
	D-4	6.2-6.9	1.89-2.10										
	D-5	10.3-10.9	3.14-3.32					100	83	64	48	37	20
	D-6	15.1-15.6	4.60-4.75										
	D-8	25.2-25.7	7.68-7.83										
	D-9	30.2-30.6	9.20-9.33					100	87	73	57	41	25
	D-10	40.1-40.6	12.22-12.37										
	D-11	50.0-50.4	15.24-15.36					100	94	78	63	49	31
	D-12	60.0-60.3	18.29-18.38					100	81	65	50	38	26
	D-13	70.0-70.7	21.34-21.55					100	87	69	56	43	31
	D-14	79.1-79.8	24.11-24.32						100	95	86	78	60
	D-15	90.2-90.9	27.49-27.71						100	97	70	52	36
	D-16	98.2-98.9	29.93-30.14						100	97	93	87	69
	D-17	110.0-110.9	33.53-33.80										
	D-18	120.2-120.9	36.64-36.85					100	94	90	85	79	68
	D-19	130.2-130.9	39.68-39.90										
	D-20	140.2-140.8	42.73-42.92							100	94	87	67
	D-21	160.1-160.8	48.80-49.01										
LP-T-1	B-1	0.5-2.0	0.15-0.61								100	99	92
	B-2	11.0-12.0	3.35-3.66					100	93	83	62	45	34
LP-T-2	B-1	0.5-2.0	0.15-0.61					100	94	85	74	66	58
LP-T-3	B-1	0.5-2.0	0.15-0.61				100	94	86	74	63	56	50
LP-T-4	B-1	0.5-2.0	0.15-0.61					100	90	72	64	57	49
LP-T-5	B-1	0.5-2.0	0.15-0.61					100	84	64	48	36	21
LP-P-1	B-2	3.0-4.0	0.91-1.22						100	97	89	77	49
LP-P-2	B-1	0.5-2.0	0.15-0.61									100	98

NOTES:

(a) Sample types
- SS - Standard split spoon
- P - Pitcher
- D - Fugro Drive
- B,b - Bulk

(b) NP - Not Plastic

(c) USCS - Unified Soil Classification System

(d) * Indicates that test has been performed and results are included in this report

FINER BY WEIGHT (partial) /8"	U S STANDARD SIEVE NO – SAND – 4	SAND – 10	SAND – 40	SAND – 100	SILT OR CLAY – 200	PARTICLE SIZE (mm) – .005	PARTICLE SIZE (mm) – .001	ATTERBERG LIMITS (b) – LL	PL	PI	USCS (c)	IN-SITU – DRY UNIT WEIGHT (pcf)	DRY UNIT WEIGHT (kg/m^3)	MOISTURE CONTENT (%)	SATURATION (%)	VOID RATIO	COMPACTED – MAXIMUM DRY DENSITY (pcf)	MAXIMUM DRY DENSITY (kg/m^3)	OPTIMUM MOISTURE (%)	SPECIFIC
											SP	107.8	1727	14.8	71.0	0.56				
											SP	107.6	1724	1.9	9.1	0.57				
	100	99	84	7	4						SP	105.4	1689	12.4	55.9	0.60				
											SP	110.6	1772	9.4	48.5	0.52				
											SP	99.4	1592	7.5	29.1	0.69				
		100	94	8	3						SP	105.4	1689	20.2	91.1	0.60				
8	63	49	28	7	5						SP-SM	127.9	2049	7.1	60.4	0.32				
3	67	56	42	31	24						SM	97.9	1568	5.3	19.8	0.72				
9	72	51	20	7	4						SW	119.8	1919	6.3	41.9	0.41				
											SW	116.0	1858	8.9	53.1	0.45				
4	48	37	20	9	6						GP-GM	128.5	2059	5.6	54.6	0.28				2
											GM	122.3	1959	5.0	35.8	0.38				
											GM	120.6	1932	4.9	33.3	0.40				
3	57	41	25	18	16						GM	130.3	2087	7.2	66.3	0.29				
											SM	131.4	2105	6.3	60.3	0.28				
8	63	49	31	18	13						SM	112.7	1805	11.9	64.9	0.49				
5	50	38	26	16	12						GW-GM	129.6	2076	9.6	86.4	0.30				
9	56	43	31	22	18						GM	125.8	2015	7.6	60.5	0.34				
5	86	78	60	44	37						SM	108.5	1738	14.7	71.8	0.55				
7	70	52	36	22	15						SM	118.8	1905	9.4	60.7	0.42				
7	93	87	69	43	29						SM	110.4	1768	11.1	57.0	0.53				
											SM	110.6	1772	10.1	52.1	0.52				
0	85	79	68	48	37						SM	113.0	1810	9.1	50.0	0.49				
											SM	122.6	1964	9.4	67.8	0.37				
00	94	87	67	37	24						SM	116.4	1865	11.0	66.4	0.45				
											SM	127.3	2039	6.6	55.1	0.32				
	100	99	92	25	10						SP-SM						117.5	1882	8.2	2
3	62	45	34	10	7						SP-SM									
5	74	66	58	31	23						SM						131.0	2098	8.0	
4	63	56	50	28	19						SM						128.0	2050	9.5	
2	64	57	49	37	29			24	19	5	GM-GC									
4	48	36	21	13	10						GW-GM									
7	89	77	49	10	7						SP-SM									
		100	98	13	2						SP									

-1

RG (b) PI	USCS (c)	IN-SITU DRY UNIT WEIGHT (pcf)	IN-SITU DRY UNIT WEIGHT (kg/m^3)	IN-SITU MOISTURE CONTENT (%)	IN-SITU SATURATION (%)	IN-SITU VOID RATIO	COMPACTED MAXIMUM DRY DENSITY (pcf)	COMPACTED MAXIMUM DRY DENSITY (kg/m^3)	COMPACTED OPTIMUM MOISTURE (%)	SPECIFIC GRAVITY OF SOLIDS	TRIAXIAL (d)	UNCONFINED COMPRESSION	DIRECT SHEAR	CONSOLIDATION	CHEMICAL	CBR
	SP	107.8	1727	14.8	71.0	0.56							*			
	SP	107.6	1724	1.9	9.1	0.57										
	SP	105.4	1689	12.4	55.9	0.60										
	SP	110.6	1772	9.4	48.5	0.52										
	SP	99.4	1592	7.5	29.1	0.69										
	SP	105.4	1689	20.2	91.1	0.60										
	SP-SM	127.9	2049	7.1	60.4	0.32										
	SM	97.9	1568	5.3	19.8	0.72									*	
	SW	119.8	1919	6.3	41.9	0.41										
	SW	116.0	1858	8.9	53.1	0.45										
	GP-GM	128.5	2059	5.6	54.6	0.28				2.63						
	GM	122.3	1959	5.0	35.8	0.38										
	GM	120.6	1932	4.9	33.3	0.40									*	
	GM	130.3	2087	7.2	66.3	0.29										
	SM	131.4	2105	6.3	60.3	0.28										
	SM	112.7	1805	11.9	64.9	0.49										
	GW-GM	129.6	2076	9.6	86.4	0.30										
	GM	125.8	2015	7.6	60.5	0.34									*	
	SM	108.5	1738	14.7	71.8	0.55										
	SM	118.8	1905	9.4	60.7	0.42					*					
	SM	110.4	1768	11.1	57.0	0.53					*					
	SM	110.6	1772	10.1	52.1	0.52									*	
	SM	113.0	1810	9.1	50.0	0.49										
	SM	122.6	1964	9.4	67.8	0.37										
	SM	116.4	1865	11.0	66.4	0.45										
	SM	127.3	2039	6.6	55.1	0.32										
	SP-SM						117.5	1882	8.2	2.64						*
	SP-SM														*	
	SM						131.0	2098	8.0							*
	SM						128.0	2050	9.5							*
5	GM-GC														*	
	GW-GM															
	SP-SM															
	SP															

SUMMARY OF LABORATORY TEST RESULTS
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 9-1
3 OF 4

FUGRO NATIONAL, INC.

AFV-01

2

3

ACTIVITY NUMBER	SAMPLE NUMBER (a)	SAMPLE INTERVAL FEET	SAMPLE INTERVAL METERS	PERCENT FINER BY WEIGHT — STANDARD SIEVE OPENING — BLDRS. 24"	COBBLES 12"	COBBLES 6"	GRAVEL 3"	GRAVEL 1½"	GRAVEL 3/4"	GRAVEL 3/8"	U S STANDARD SI — SAND 4	SAND 10	SAND 40
LP-P-7	b-1	0.5-2.0	0.15-0.61								100	99	95
LP-P-9	b-1	0.25-2.0	0.08-0.61						100	86	80	75	68
LP-P-11	B-1	0.5-2.0	0.15-0.61							100	97	95	87
LP-P-14	B-1	0.1-2.0	0.03-0.61					100	85	66	54	41	15
LP-P-15	B-1	0.25-2.0	0.08-0.61							100	99	96	90
LP-P-19	B-1	0.25-1.5	0.08-0.46					100	76	66	57	52	44
LP-P-21	B-1	0.25-2.0	0.08-0.61					100	92	78	59	42	18
LP-P-24	b-1	0.25-1.5	0.08-0.46					100	85	74	67	59	42
LP-P-27	b-1	0.5-2.0	0.15-0.61					100	84	54	37	27	19
LP-P-28	b-1	0.25-1.0	0.08-0.30					100	91	66	54	48	40
LP-CS-1	B-1	0.25-2.0	0.08-0.61									100	92
LP-CS-14	B-1	0.25-2.0	0.08-0.61						100	96	86	76	65
LP-CS-21	b-1	0.5-2.0	0.15-0.61						100	97	94	92	83
LP-CS-29	b-1	0.25-2.0	0.08-0.61						100	97	97	96	88
LP-CS-32	B-1	0.25-2.0	0.08-0.61					100	78	58	48	40	31
LP-CS-38	B-1	0.25-2.0	0.08-0.61						100	95	85	77	70
LP-CS-47	B-1	0.25-2.0	0.08-0.61				100	98	90	81	68	59	49
LP-CS-57	b-1	0.25-1.0	0.08-0.30					100	91	74	64	58	49
LP-CS-62	b-1	0.25-1.5	0.08-0.46					100	98	91	85	76	57

NOTES:

(a) Sample types
- SS - Standard split spoon
- P - Pitcher
- D - Fugro Drive
- B,b - Bulk

(b) NP - Not Plastic

(c) USCS - Unified Soil Classification System

(d) * Indicates that test has been performed and results are included in this report

	(pcf)	(kg/m³)				(pcf)	(kg/m³)			
SM										
SM										
SM										
SP										
CL-ML										
GC						127.3	2039	10.4		
SP										
SM										
GP-GM									2.68	
GM										
SM						120.6	1932	9.0		
SC-SM						133.0	2130	8.0		
SM										
SP-SM										
GP-GM										
CL									2.70	
SM						122.5	1962	12.5		
GM										
SM										

BERG S (b)		USCS (c)	IN-SITU					COMPACTED			SPECIFIC GRAVITY OF SOLIDS	TRIAXIAL (d)	UNCONFINED COMPRESSION	DIRECT SHEAR	CONSOLIDATION	CHEMICAL	CBR
			DRY UNIT WEIGHT		MOISTURE CONTENT (%)	SATURATION (%)	VOID RATIO	MAXIMUM DRY DENSITY		OPTIMUM MOISTURE (%)							
L	PI		(pcf)	(kg/m³)				(pcf)	(kg/m³)								
		SM															
		SM															
5	2	SM															
		SP															
4	7	CL-ML															
19	11	GC						127.3	2039	10.4							*
		SP															
		SM															
		GP-GM									2.68						
27	3	GM															
		SM						120.6	1932	9.0							*
25	4	SC-SM						133.0	2130	8.0							*
		SM															
		SP-SM															
		GP-GM															
22	11	CL									2.70						
24	9	SM						122.5	1962	12.5							*
		GM															
		SM															

SUMMARY OF LABORATORY TEST RESULTS
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 9-1
4 OF 4

FUGRO NATIONAL, INC.

AFV-01

BORING NO.	SAMPLE NO.	SAMPLE INTERVAL FEET	SAMPLE INTERVAL METERS	SOIL TYPE	TYPE OF TEST	DRY DENSITY pcf	DRY DENSITY kg/m^3	MOISTURE CONTENT (%)	CONFINING PRESSURE (σ_3) ksf	CONFINING PRESSURE (σ_3) kN/m^2	MAXIMUM DEVIATOR STRESS ($\sigma_1-\sigma_3$) ksf	MAXIMUM DEVIATOR STRESS ($\sigma_1-\sigma_3$) kN/m^2	STRAIN RATE (% min)	BACK PRESSURE ksf	BACK PRESSURE kN/m^2
LP-B-6	D-15	90.2-90.9	27.49-27.71	SM	CD	118.8	1903	9.4	8.9	426	34.0	1628	0.07	0	0
	D-16	98.2-98.9	29.93-30.14	SM	CD	110.4	1768	11.1	15.0	718	45.8	2193	0.07	0	0

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SUMMARY OF TRIAXIAL COMPRESSION TEST RESULTS
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 9-2

FUGRO NATIONAL, INC.

BORING NO.	SAMPLE NO.	SAMPLE INTERVAL		SOIL TYPE	UNCONFINED COMP. STRENGTH		DRY DENSITY		MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	HEIGHT DIAMETER
		FEET	METERS		ksf	kN/m^2	pcf	kg/m^3			
LP-B-3	P-14	90.0-90.8	27.43-27.68	CH	13.0	622	91.0	1458	31.4	99.6	2.4

SUMMARY OF
UNCONFINED COMPRESSION TEST RESULTS
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 9-3

FUGRO NATIONAL, INC.

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BORING NO.	SAMPLE NO.	SAMPLE INTERVAL FEET	SAMPLE INTERVAL METERS	SOIL TYPE	NORMAL STRESS ksf	NORMAL STRESS kN/m²	MAXIMUM SHEAR STRENGTH ksf	MAXIMUM SHEAR STRENGTH kN/m²
LP-B-1	P-2	3.0-3.9	0.91-1.19	SP-SM	1.0	48	1.3	62
					2.0	96	2.1	101
					3.0	144	2.3	110
LP-B-1	P-7	25.0-25.7	7.62-7.83	SP	2.5	120	2.3	110
					5.0	239	4.6	220
					7.5	359	5.7	273
LP-B-3	P-5	15.0-16.7	4.57-5.09	SP-SM	1.5	72	1.5	72
					3.0	144	2.8	134
					4.0	192	3.9	182
LP-B-3	P-11	60.8-61.6	18.53-18.78	SP	6.0	287	3.5	163
					9.0	431	6.1	292
					12.0	575	7.9	378
LP-B-5	D-3	6.2-6.9	1.89-2.10	SP-SM	1.0	48	1.2	57
					2.0	96	1.8	86
					3.0	144	2.7	129
LP-B-5	D-13	80.2-80.9	24.44-24.66	SP	8.0	383	6.2	297
					10.0	479	8.2	393
					12.0	575	9.4	450

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SUMMARY OF DIRECT SHEAR TEST RESULTS
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE **9-4**

FUGRO NATIONAL, INC.

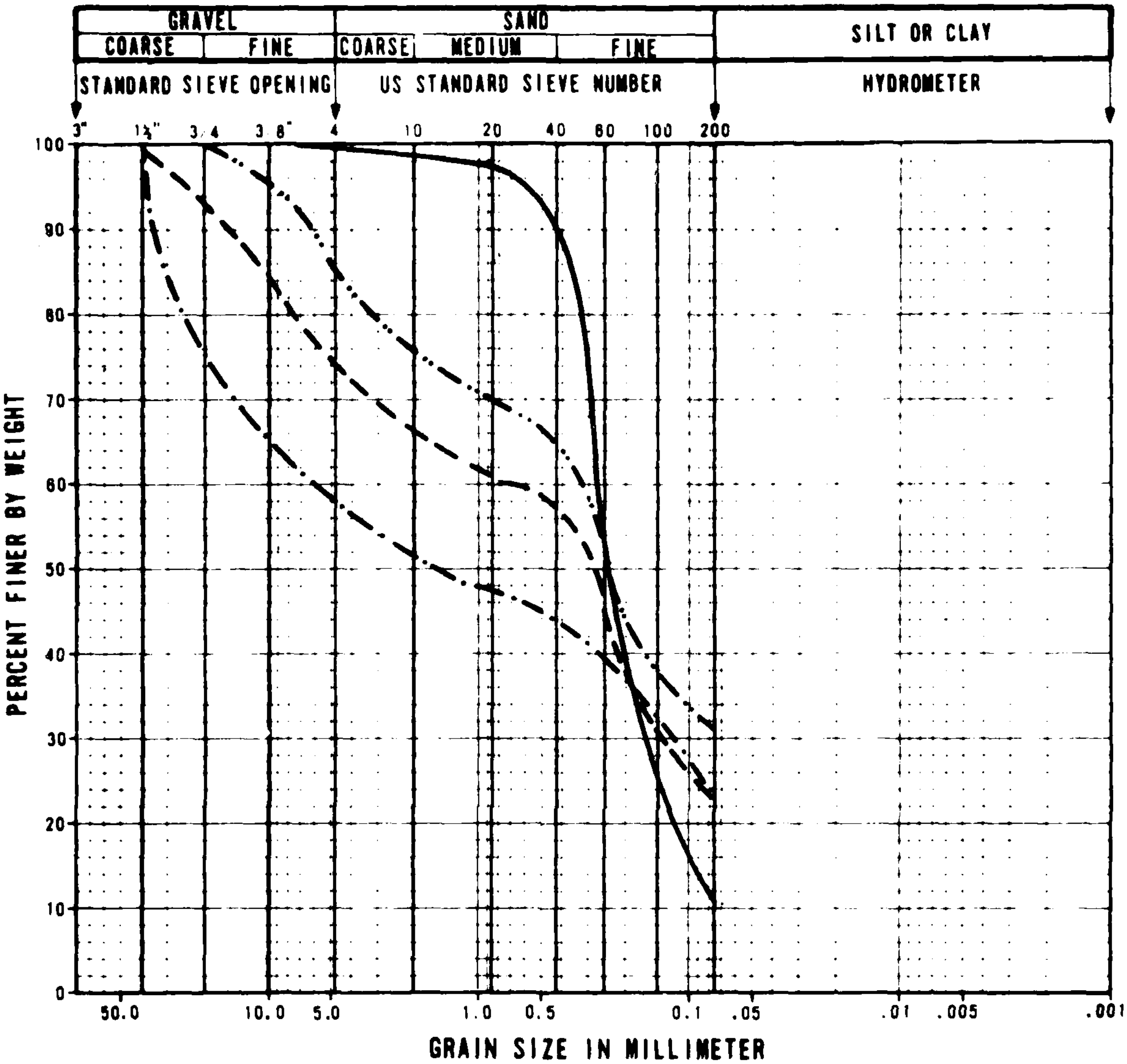
ACTIVITY NO.	SAMPLE NO.	SAMPLE INTERVAL		SOIL TYPE	pH	WATER SOLUBLE				CALCIUM CARBONATE
		FEET	METERS			SODIUM mg kg	CHLORIDE mg kg	SULPHATE mg kg	CALCIUM mg kg	mg kg
LP-B-1	P-2	3.9-4.7	1.19-1.43	SP-SM	6.9	58	10	132	44	319
	P-5	15.5-16.6	4.72-5.06	SP	6.9	667	549	175	62	300
LP-B-2	P-4	10.0-10.9	3.05-3.32	SM	7.1	664	713	17	50	265
	P-16	120.3-121.1	36.67-36.91	SM	7.2	122	61	1071	65	390
LP-B-3	P-2	3.2-4.2	0.98-1.28	CL-ML	6.9	1260	3552	1395	156	4287
	P-12	71.1-72.0	21.67-21.95	CH	7.1	53	49	241	94	328
LP-B-6	D-1	0.2-0.9	0.06-0.27	SM	7.0	59	19	342	50	216
	D-8	25.2-25.7	7.68-7.83	GM	7.9	360	108	2251	70	392
	D-13	70.0-70.7	21.34-21.55	GM	7.5	525	184	133	55	238
	D-17	110.2-110.9	33.59-33.80	SM	7.5	251	146	167	56	232
LP-T-1	B-2	11.0-12.0	3.35-3.66	SP-SM	7.5	391	408	360	108	337
LP-T-4	B-1	0.3-2.0	0.09-0.61	GM-GC	7.4	1302	2208	786	764	2120

SUMMARY OF CHEMICAL TEST RESULTS
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 9-5

FUGRO NATIONAL, INC.



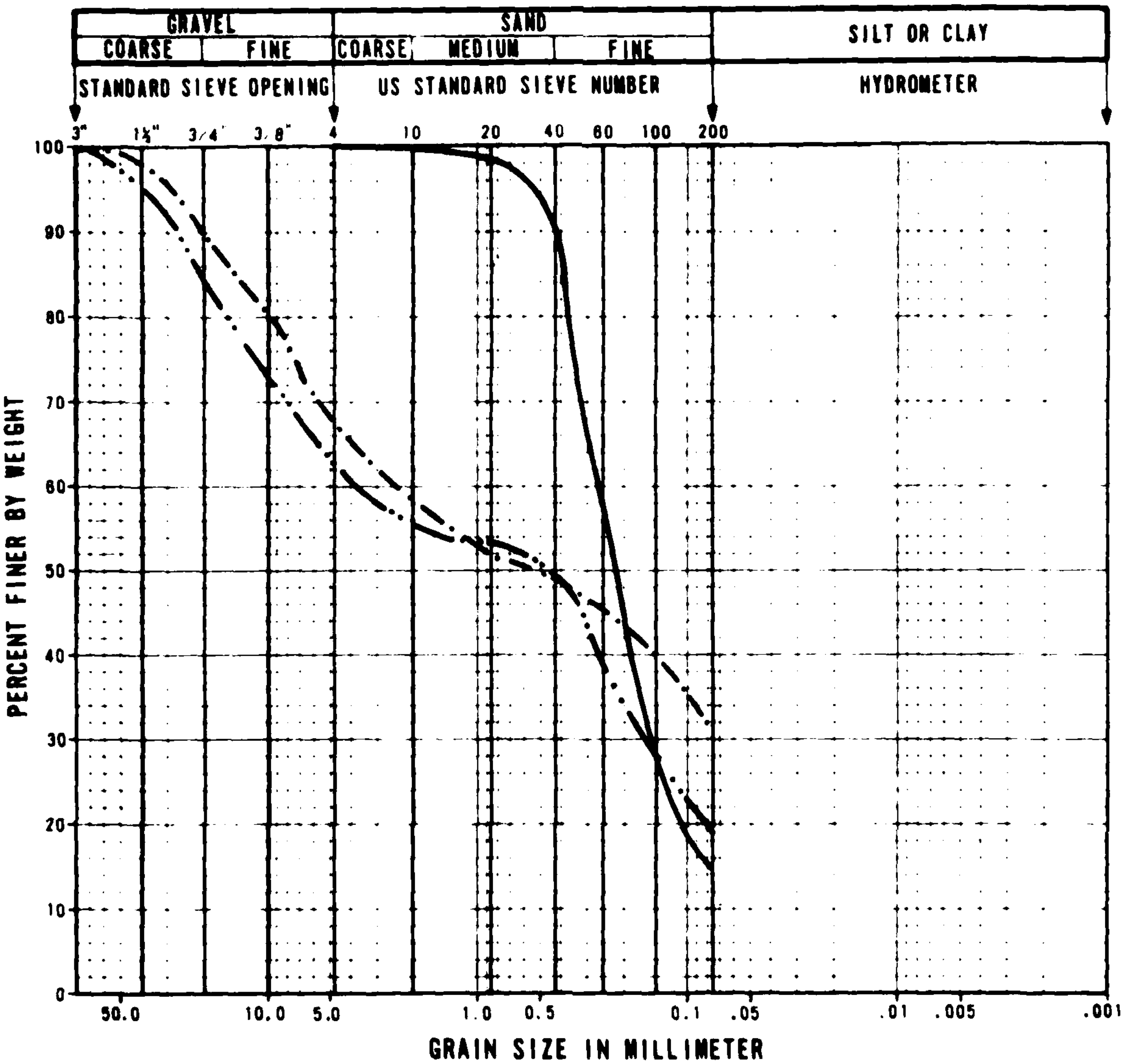
SYMBOL	COMPOSITE SAMPLE NUMBER	ACTIVITY NUMBER	SAMPLE INTERVAL		SOIL TYPE
			FEET	METERS	
———	A	LP-T 1	0.5-2.0	0.15-0.61	SP SM
— — —	B	LP-T-2	0.5-2.0	0.15-0.61	SM
—·—	C	LP-P-19	0.25-1.5	0.08-0.46	GC
—··—	D	LP CS 14	0.25-2.0	0.08-0.61	SC-SM

GRAIN SIZE CURVES, CBR TESTS
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 9-1

FUGRO NATIONAL, INC.



SYMBOL	COMPOSITE SAMPLE NUMBER	ACTIVITY NUMBER	SAMPLE INTERVAL FEET	SAMPLE INTERVAL METERS	SOIL TYPE
———	E	LP-CS-1	0.25-2.0	0.08-0.61	SM
—·—	F	LP-CS-47	0.25-2.0	0.08-0.61	SM
—··—	G	LP-T-3	0.5-2.0	0.15-0.61	SM

GRAIN SIZE CURVES, CBR TESTS
VERIFICATION SITE, LA POSA COP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 9-1
2 OF 2

FUGRO NATIONAL, INC.

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COMPOSITE SAMPLE NUMBER	SOIL TYPE	PERCENT PASSING #200	ATTERBERG LIMITS		SPECIFIC GRAVITY	MAXIMUM DRY DENSITY		OPTIMUM MOISTURE (%)	COMPACTED DRY DENSITY		COMPACTED MOISTURE (%)	PERCENT OF MAXIMUM DRY DENSITY	CBR (%)
			LL	PI		pcf	kg m3		pcf	kg m3			
A	SP-SM	10			2.64	117.5	1882	8 2	114.0	1826	7.7	97 0	24
									109.5	1754	8.1	93.2	10
B	SM	23				131.0	2098	8.0	121.4	1945	8.5	92 7	33
									114.8	1839	8.6	87 6	9
C	GC	24	30	11		127.3	2039	10.4	125.6	2012	9.0	98 7	72
									121.6	1948	9 2	95 5	37
									113.9	1825	9 7	89 5	8
D	SC-SM	31	19	4		133.0	2130	8.0	130.0	2082	8 3	97 7	94
									125.5	2010	8 4	94 4	29
									114.1	1828	8 1	85 8	4

CALIFORNIA BEARING RATIO (CBR) TEST RESULTS
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 9-6
1 OF 2

FUGRO NATIONAL, INC.

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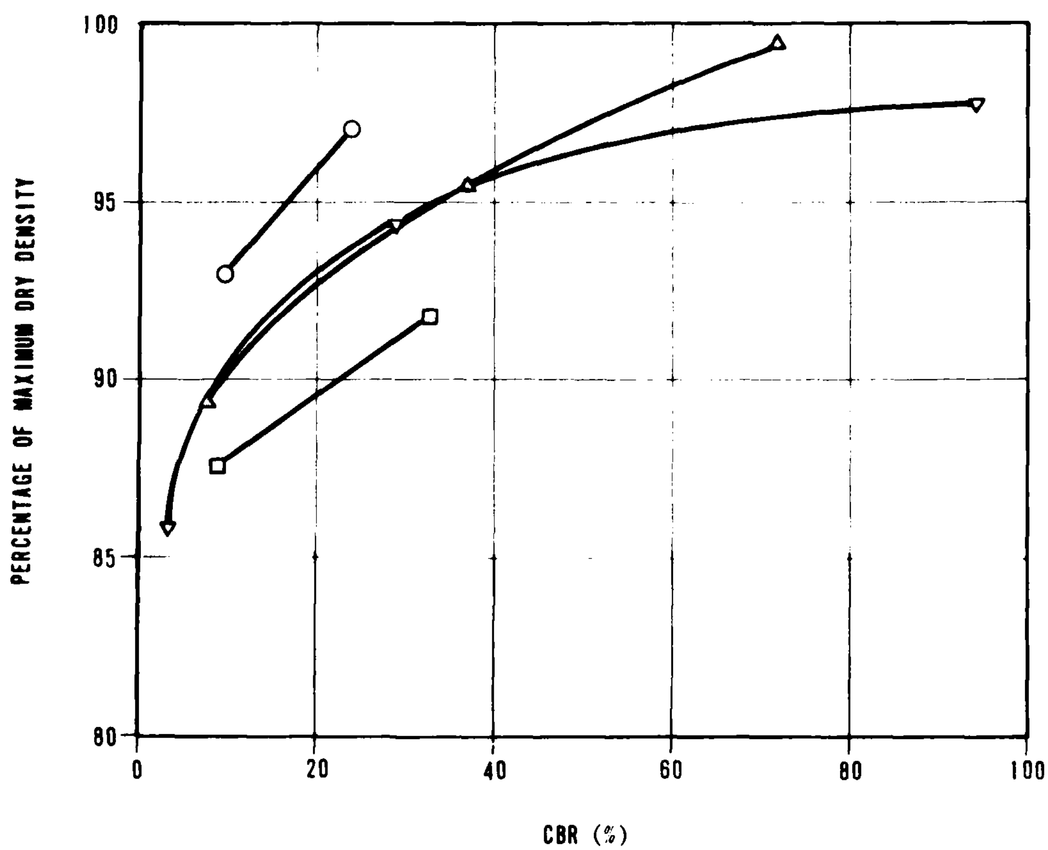
COMPOSITE SAMPLE NUMBER	SOIL TYPE	PERCENT PASSING #200	ATTERBERG LIMITS		SPECIFIC GRAVITY	MAXIMUM DRY DENSITY		OPTIMUM MOISTURE (%)	COMPACTED DRY DENSITY		COMPACTED MOISTURE (%)	PERCENT OF MAXIMUM DRY DENSITY	CBR (%)
			LL	PI		pcf	kg/m³		pcf	kg/m³			
E	SM	14				120.9	1936	9.0	116.1	1860	9.1	96.0	40
									115.5	1850	9.3	95.5	31
									108.0	1730	8.9	89.3	10
F	SM	31	33	9		122.5	1962	12.5	120.1	1924	11.4	98.0	53
									113.1	1812	12.7	92.3	23
									109.7	1757	11.5	89.6	10
G	SM	19				128.0	2050	9.5	124.7	1997	9.8	97.4	102
									120.6	1932	10.0	94.2	60
									113.9	1824	10.0	89.0	25

CALIFORNIA BEARING RATIO (CBR) TEST RESULTS
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 9-6
2 OF 2

FUGRO NATIONAL, INC.



SYMBOL	COMPOSITE SAMPLE NUMBER	SOIL TYPE
○	A	SP-SM
□	B	SM
△	C	GC
▽	D	SC-SM

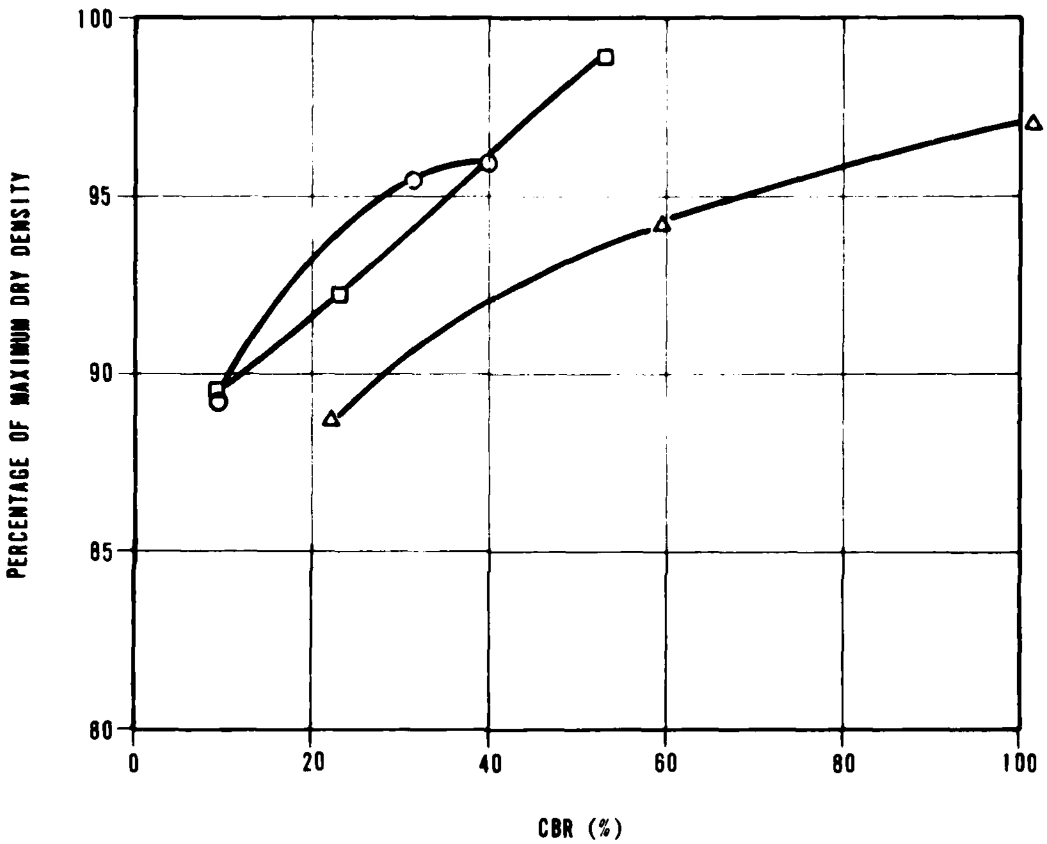
CALIFORNIA BEARING RATIO (CBR) CURVES
VERIFICATION SITE, LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 9-2
1 OF 2

FUGRO NATIONAL, INC.

CHECKED BY ____ APPROVED BY ____



SYMBOL	COMPOSITE SAMPLE NUMBER	SOIL TYPE
○	E	SM
□	F	SM
△	G	SM

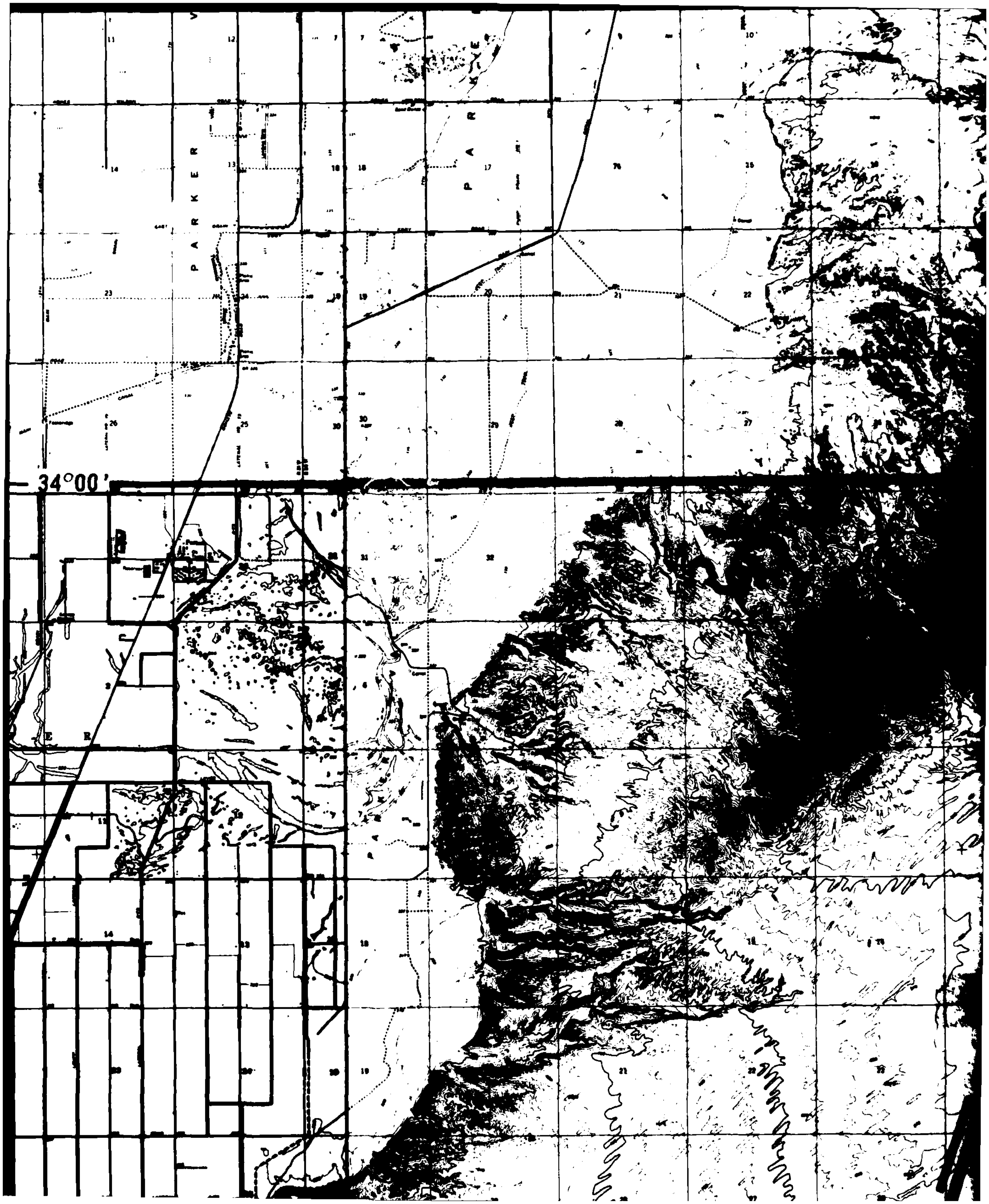
CALIFORNIA BEARING RATIO (CBR) CURVES
VERIFICATION SITE, LA POSA CDP, ARIZONA

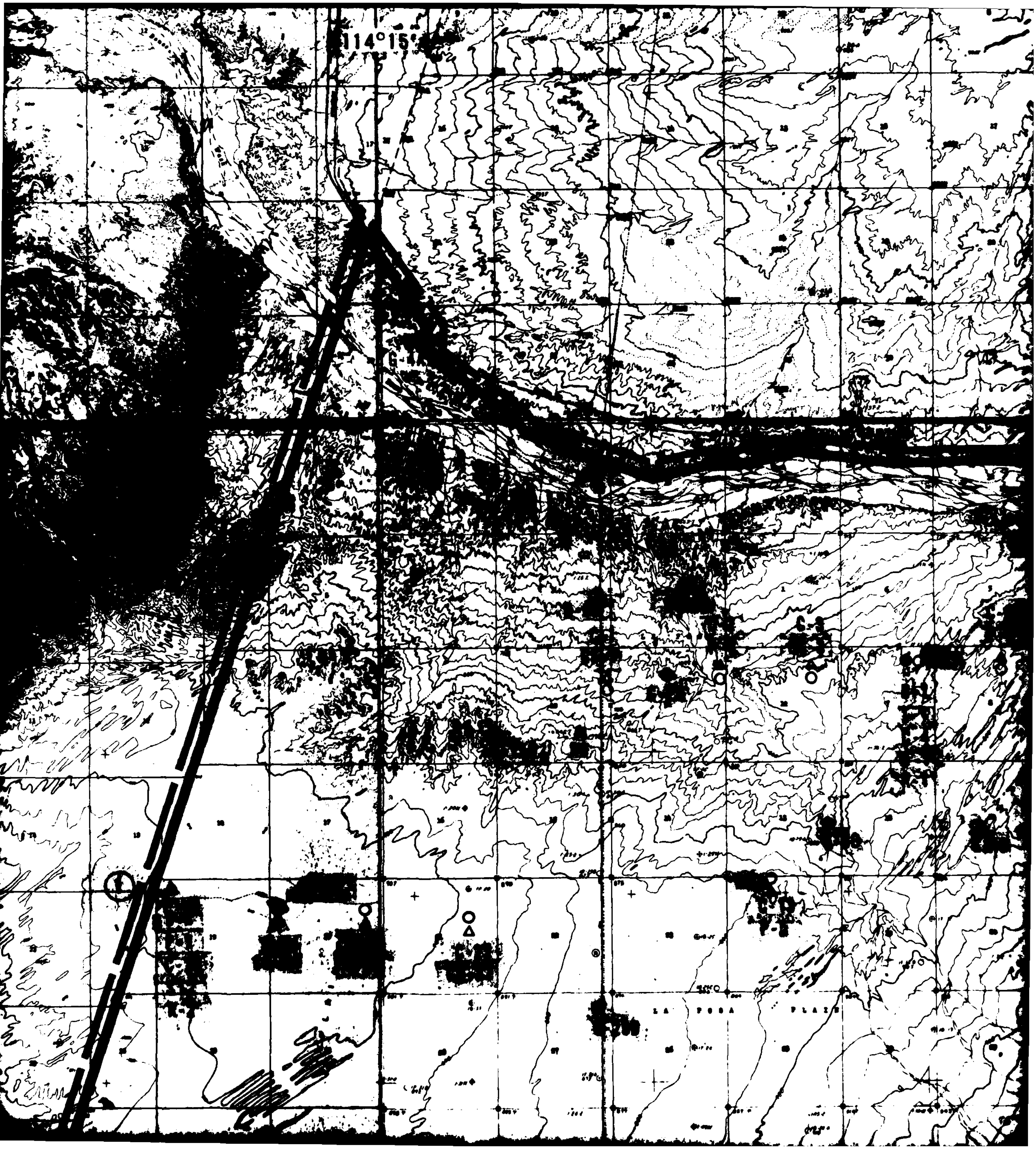
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

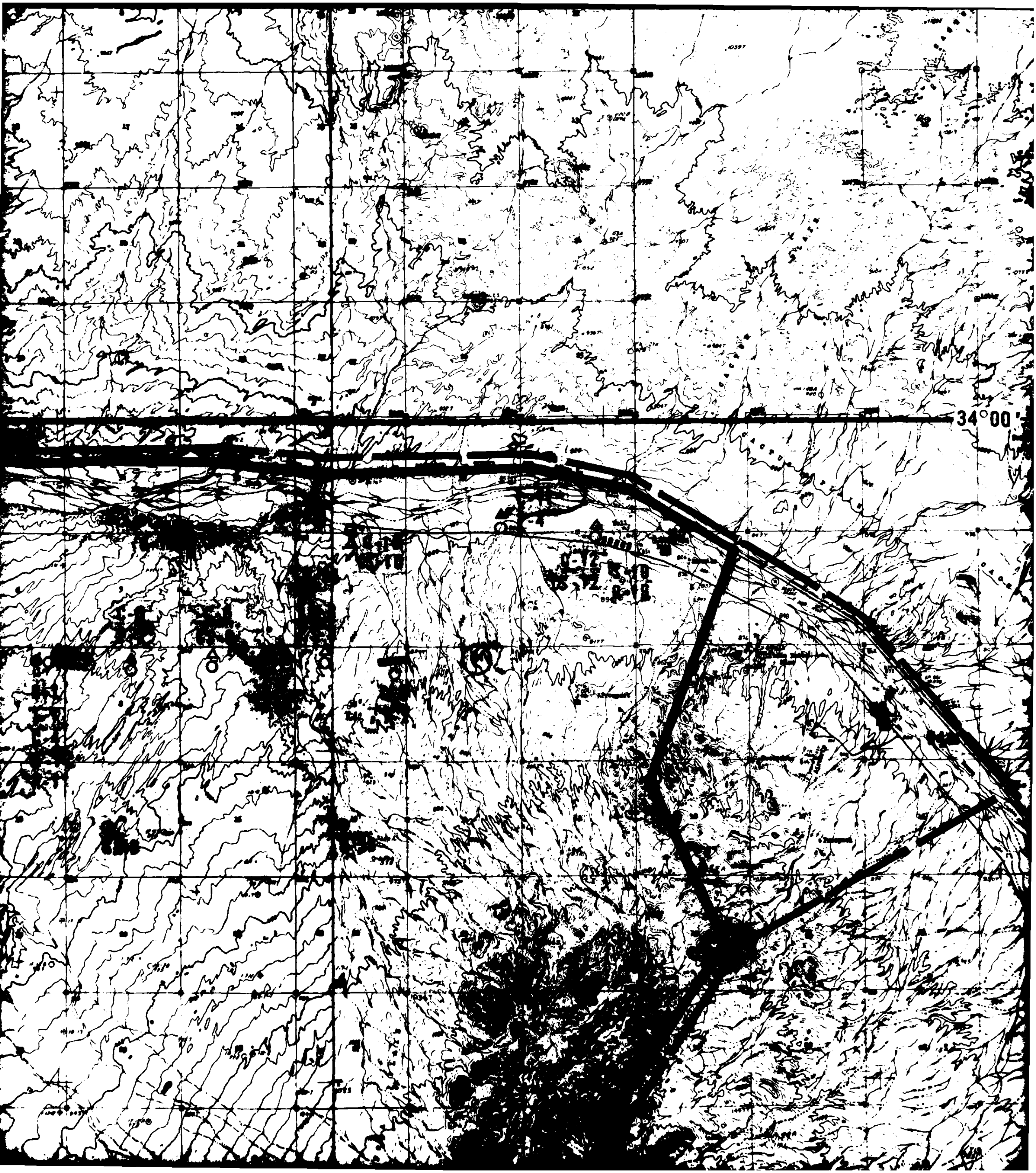
FIGURE
9-2
2 OF 2

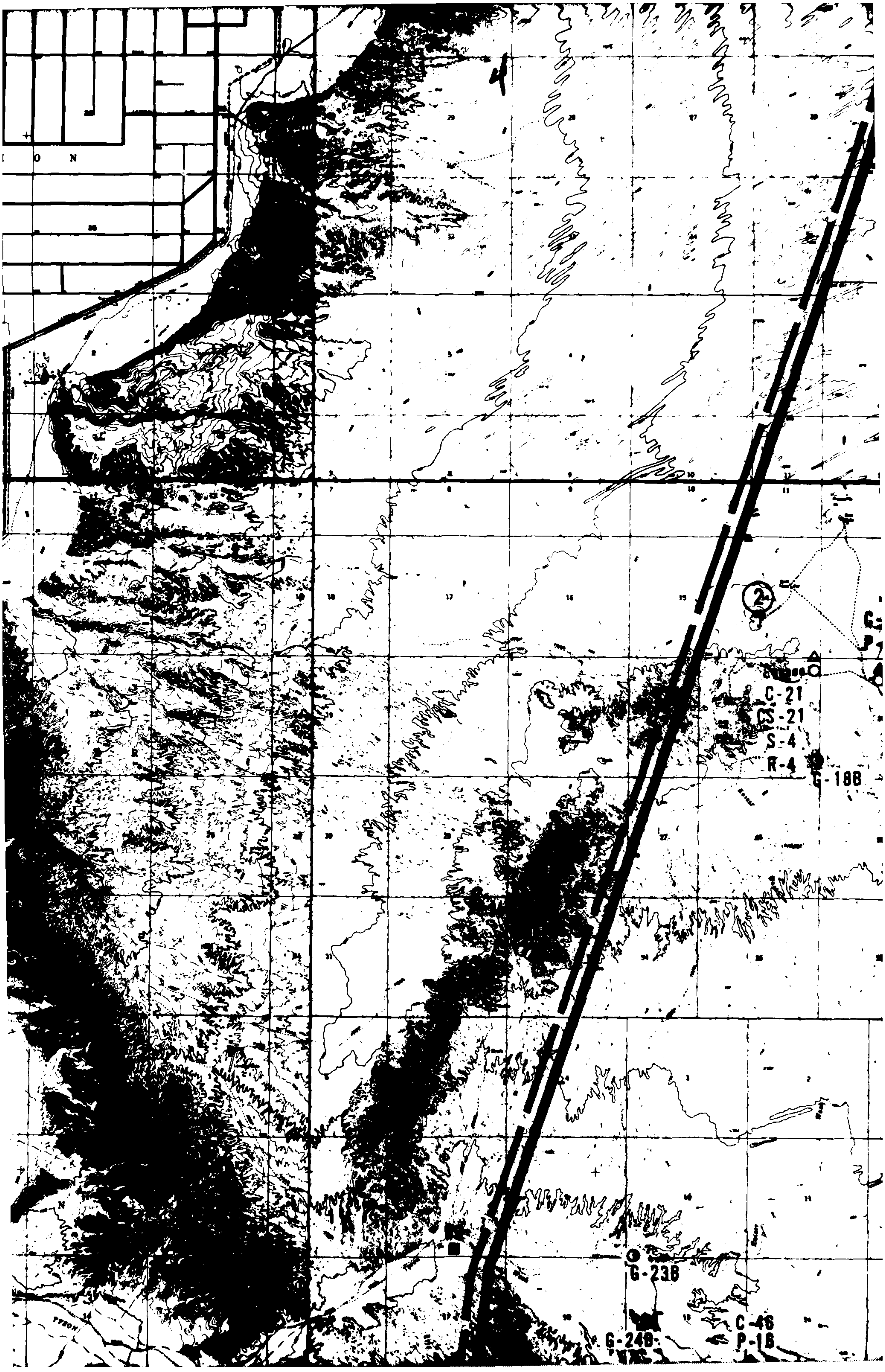
FUGRO NATIONAL, INC.

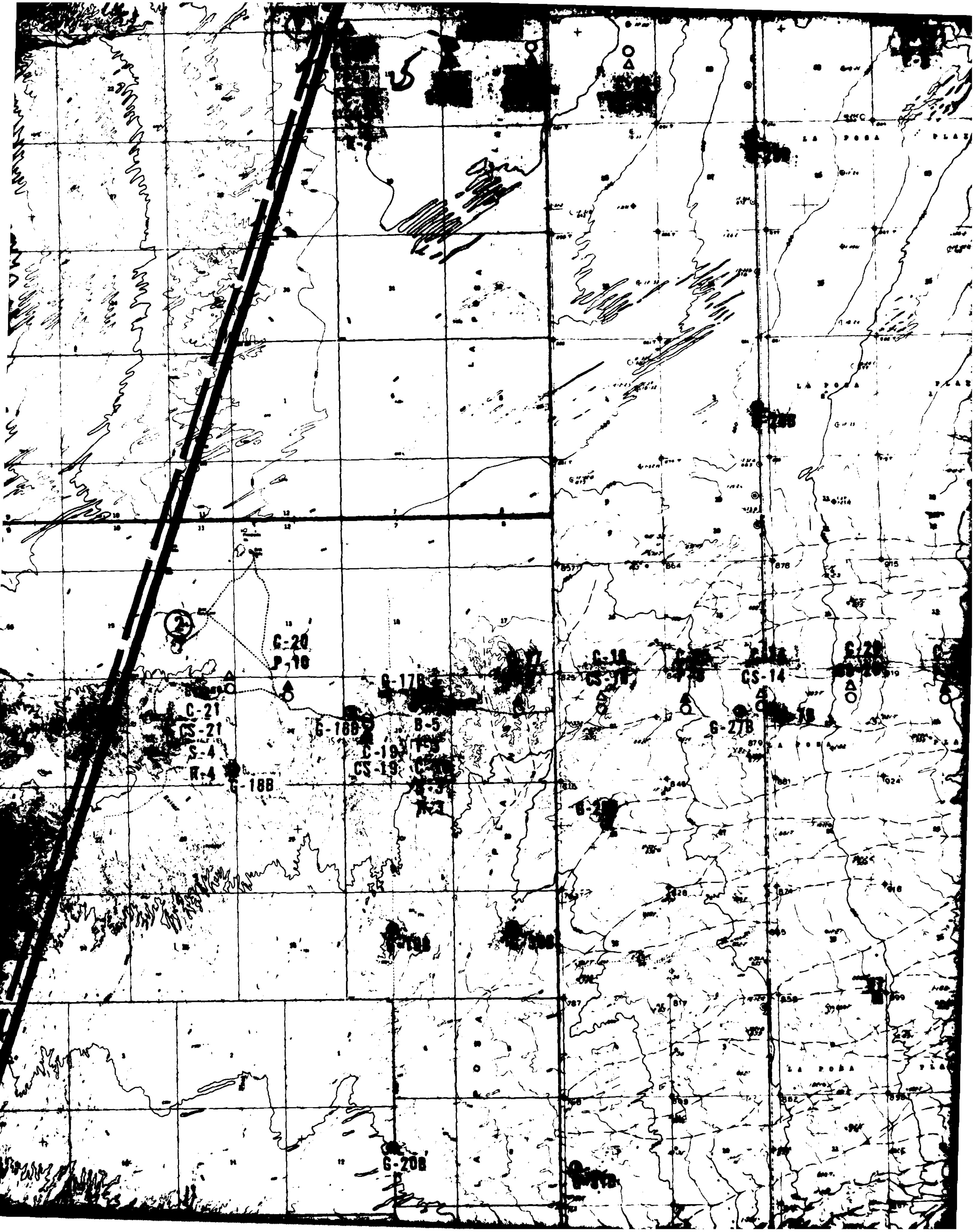
CHECKED BY ____ APPROVED BY ____


34°00'
PARKER

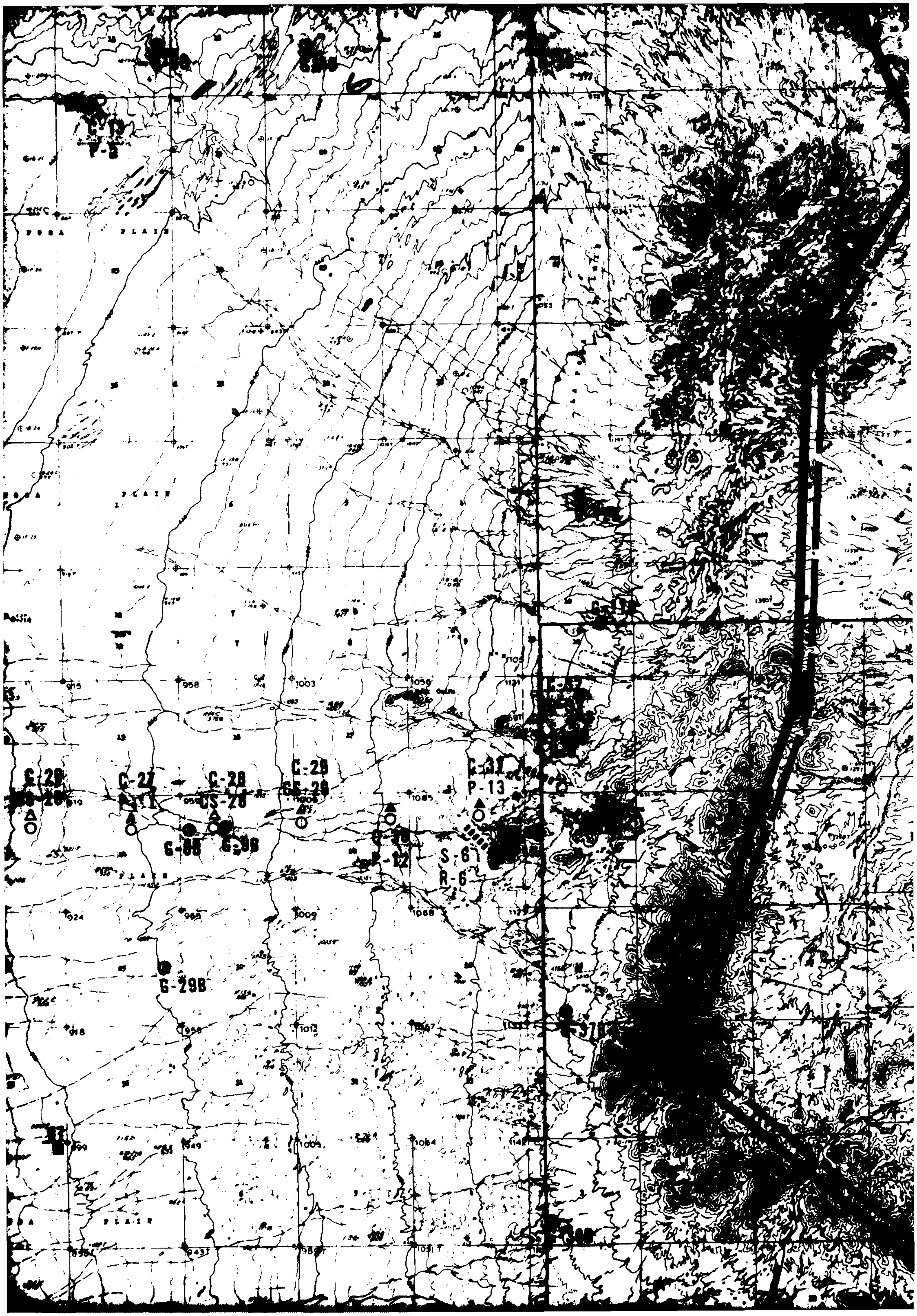

114°15'
LA POSA PLAIN


34°00'

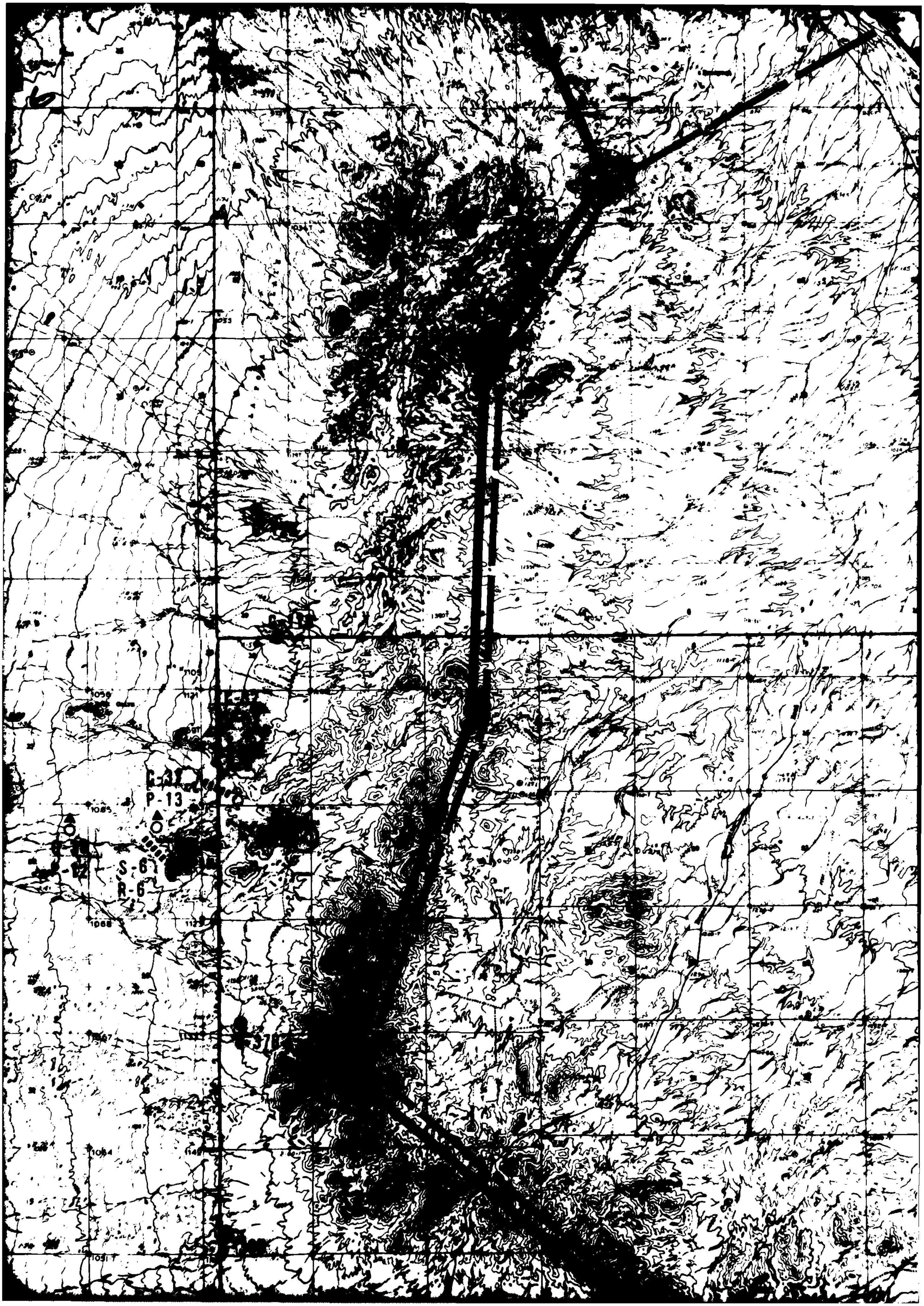

2
C-21
CS-21
S-4
R-4
G-18B
G-23B
G-24B
C-4B
P-1B

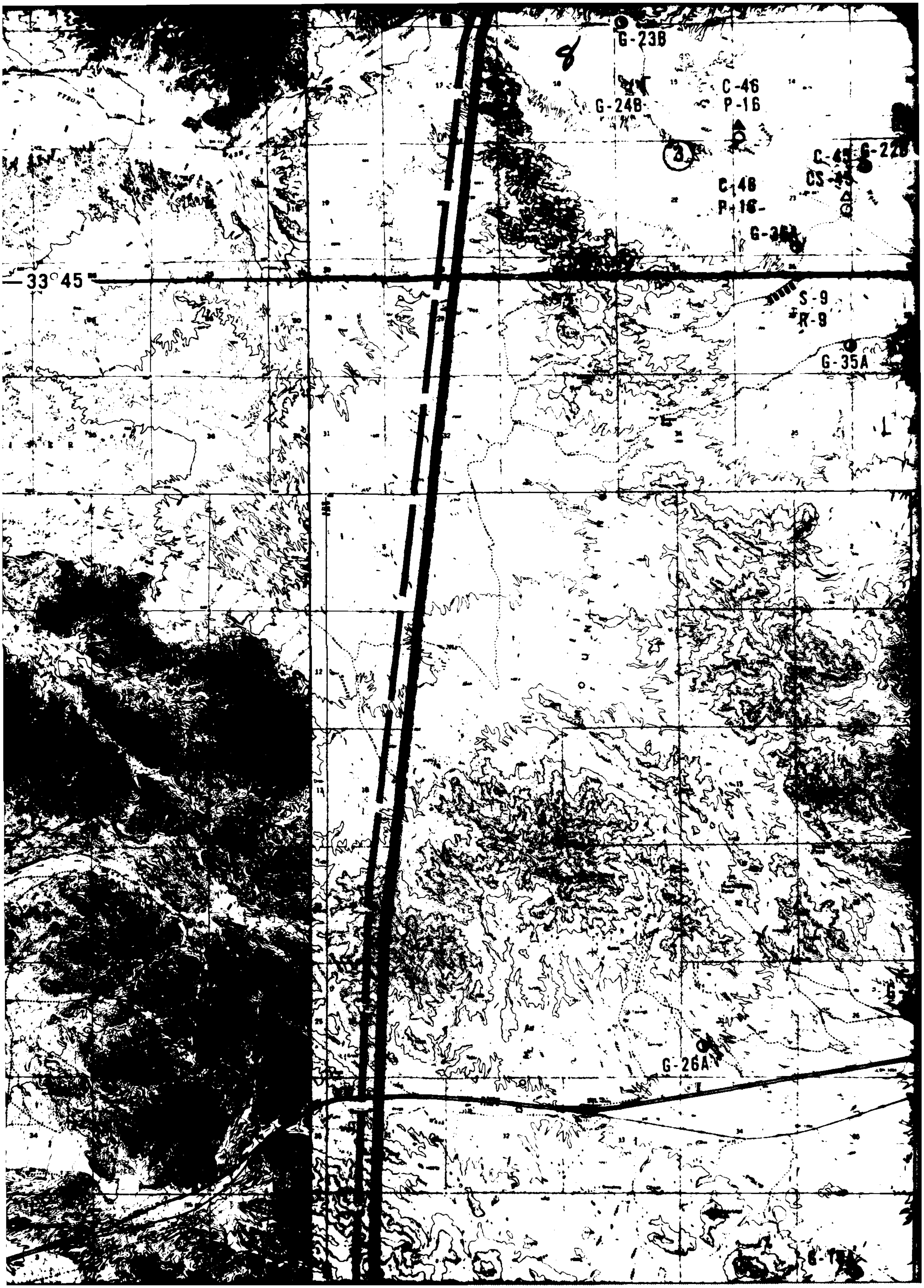


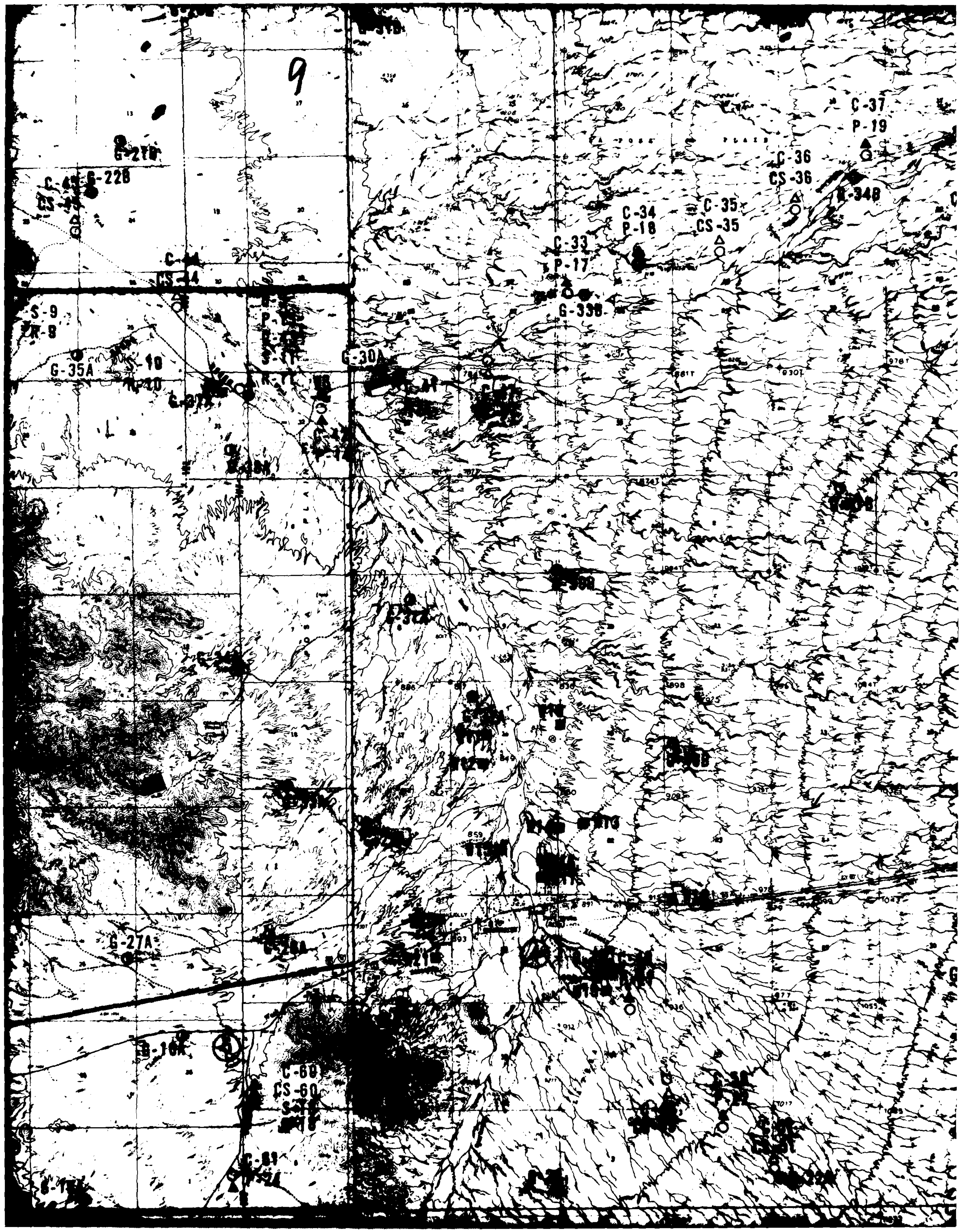
G-20
P-10
G-17B
C-21
CS-21
S-4
R-4
G-18B
B-5
C-19
CS-19
CS-14
G-27B
G-20B
LA POSA

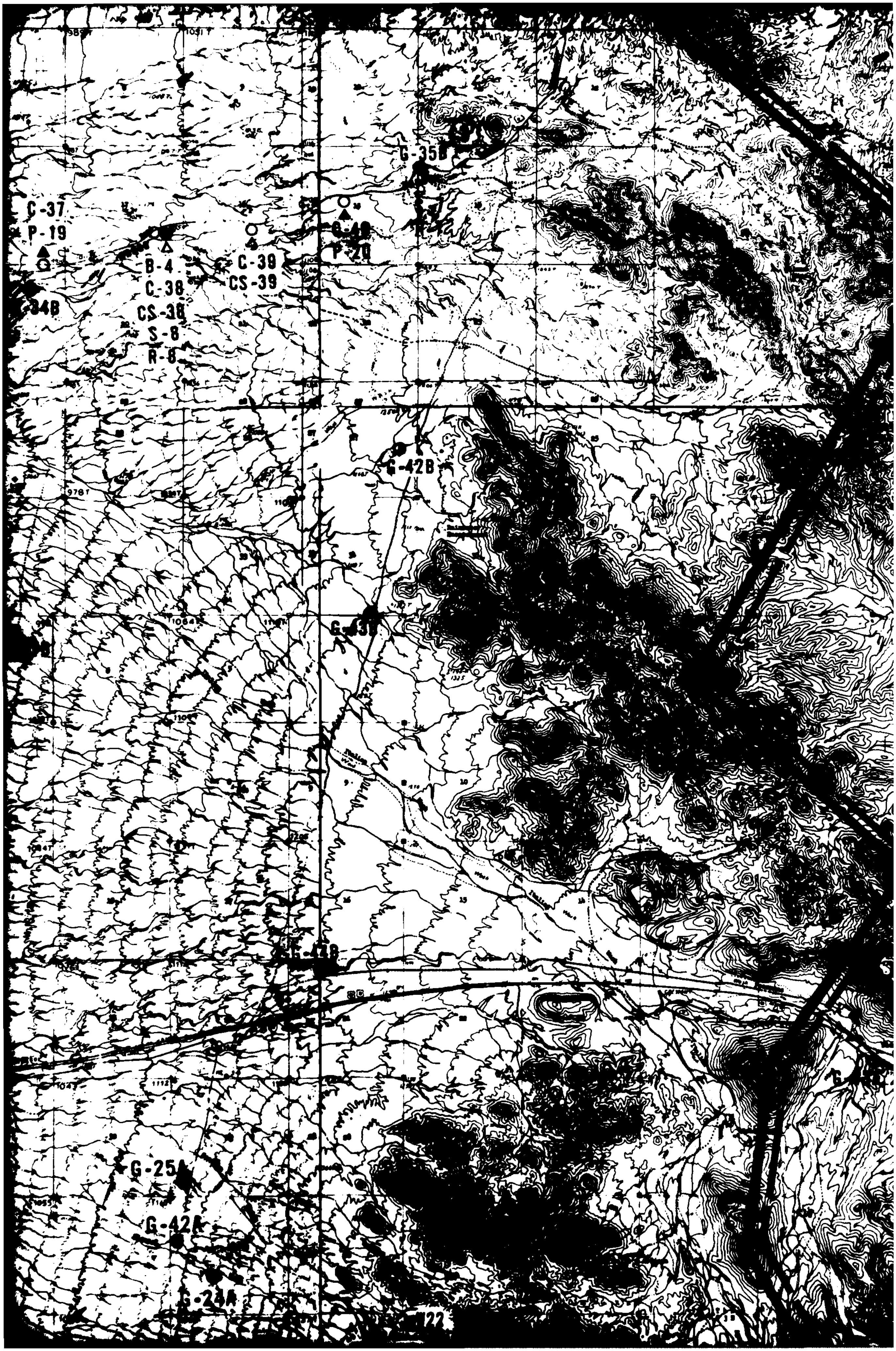


C-29
C-27
C-28
C-29
P-13
S-6
R-6
P-12
G-88
G-29B
915
958
1003
1059
1085
924
965
1009
1068
918
1012
949
1064

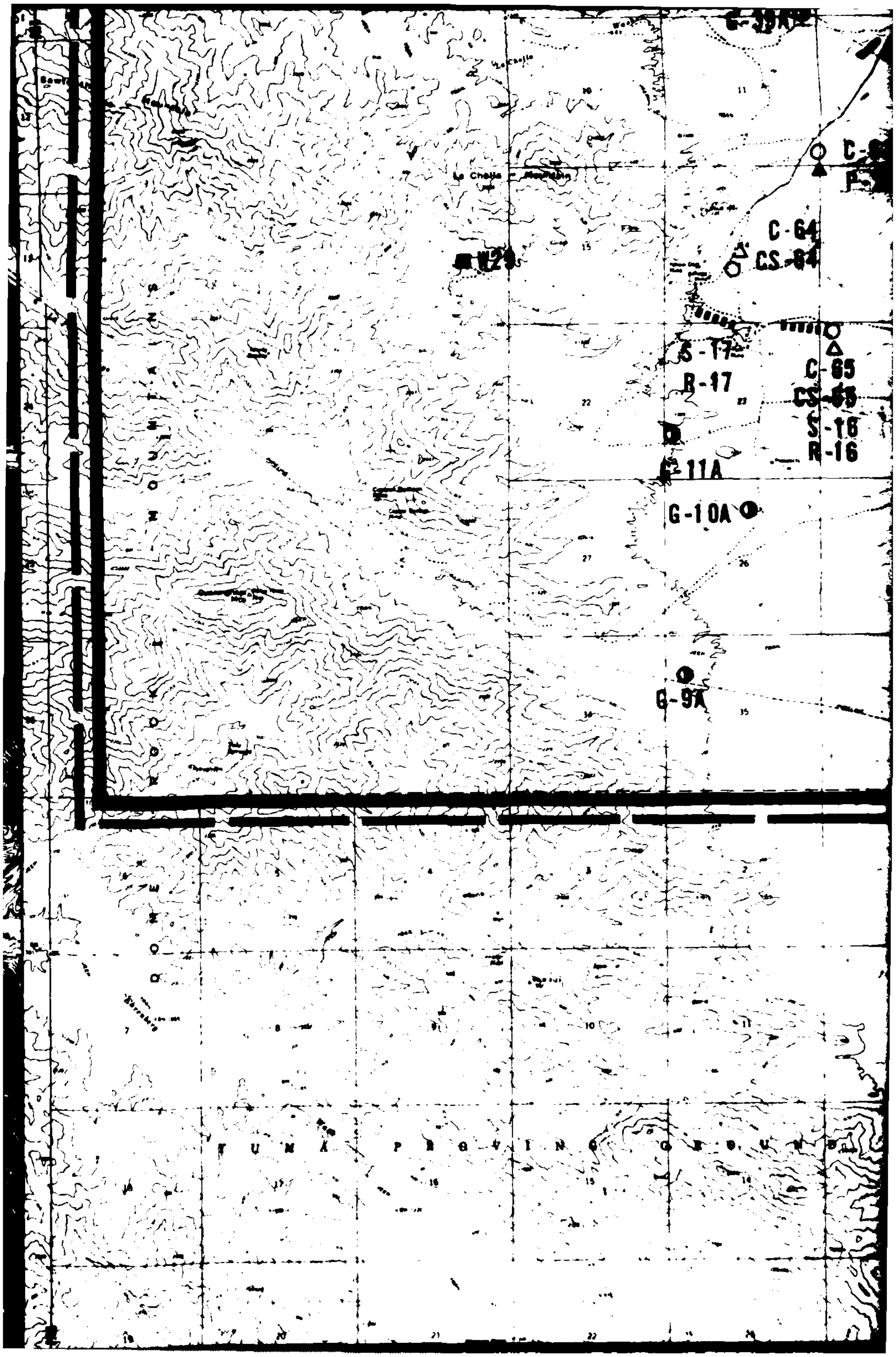

P-13
S-6
R-6

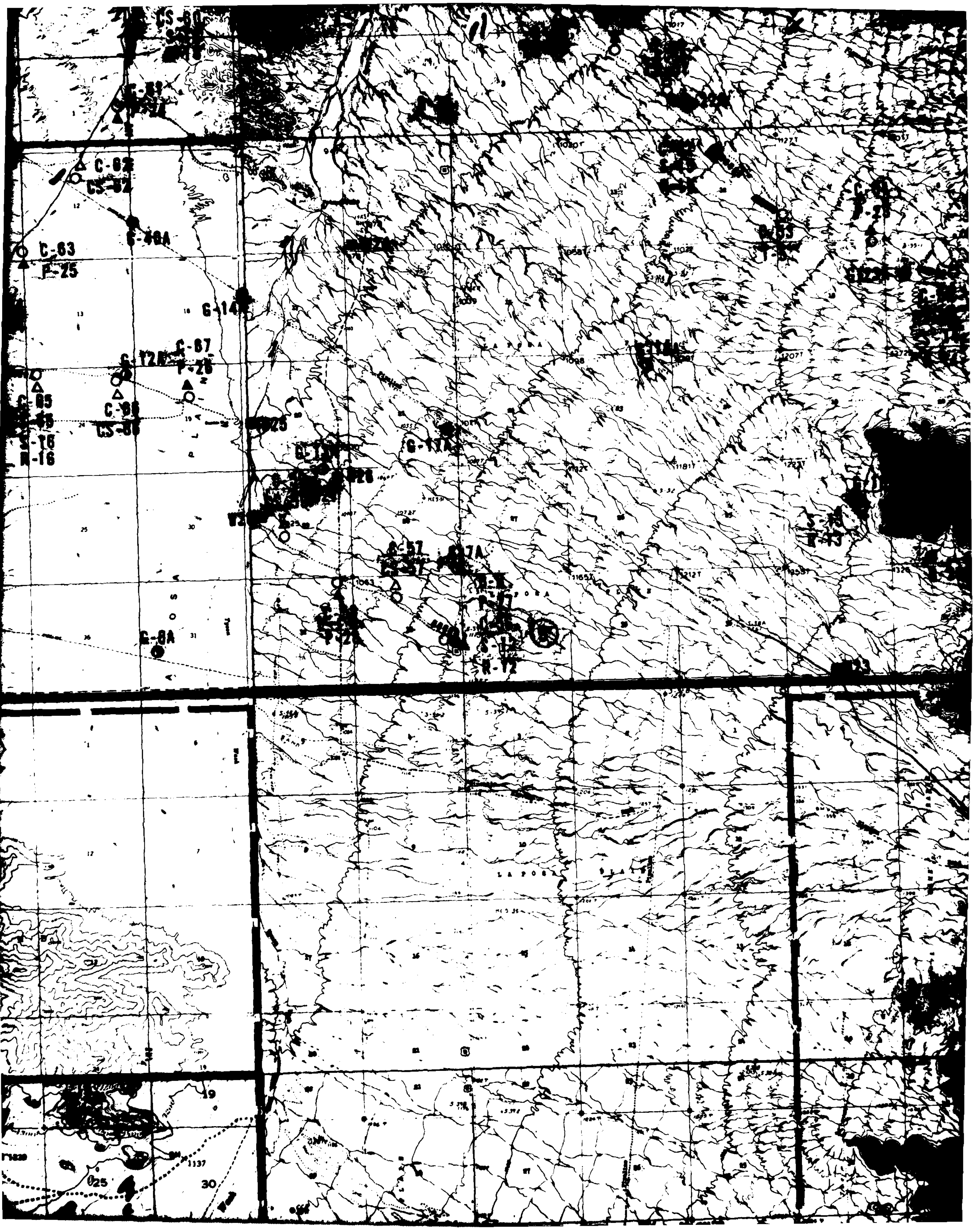

G-23B
8
C-46
P-16
G-24B
2
C-45
G-22B
CS-45
C-46
P-16
33°45'
S-9
R-9
G-35A
G-26A

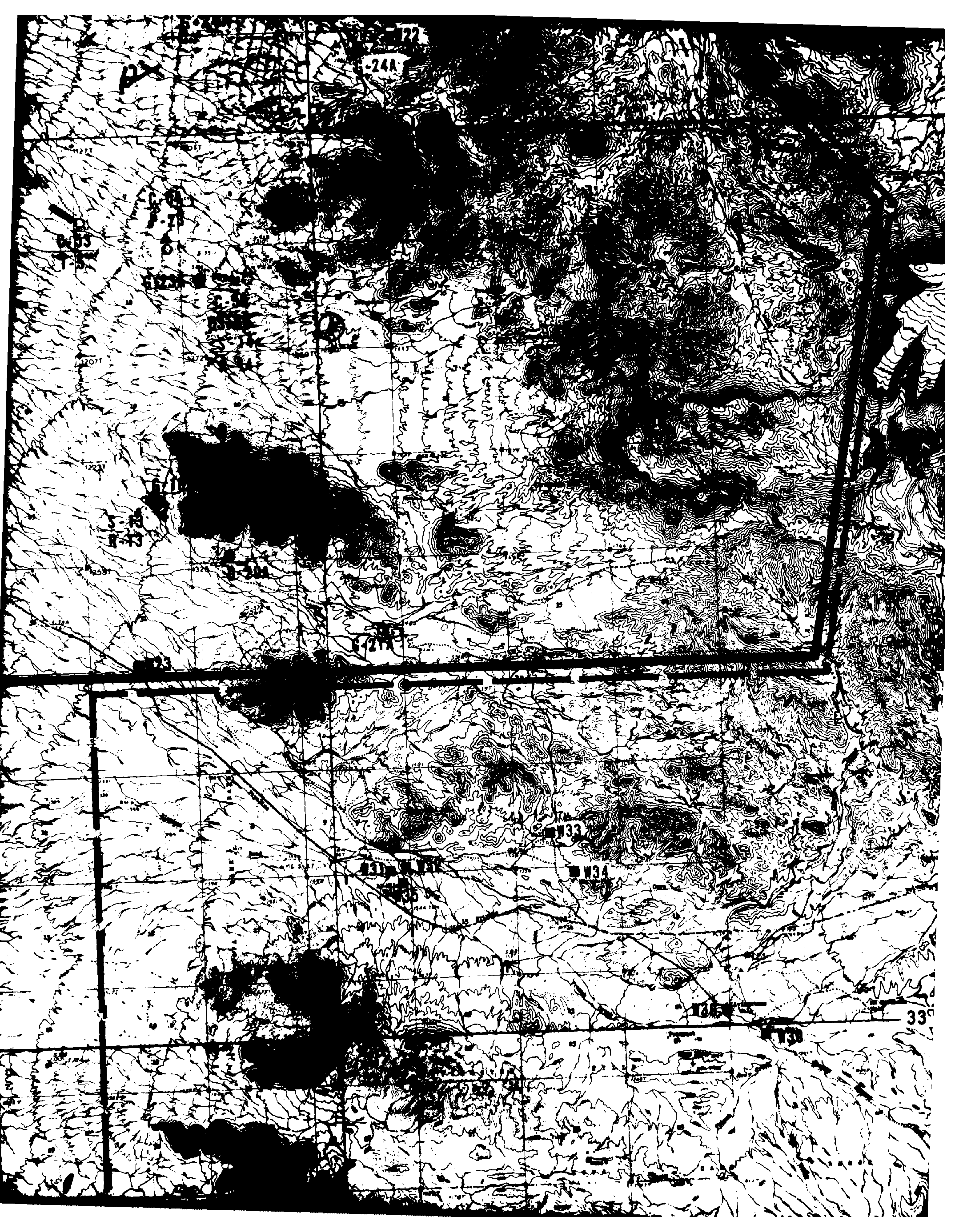

9
C-37
P-19
C-36
CS-36
C-35
CS-35
C-34
P-18
C-33
P-17
G-33B
G-27B
G-22B
S-9
G-35A
G-30A
G-27A
C-60
CS-60



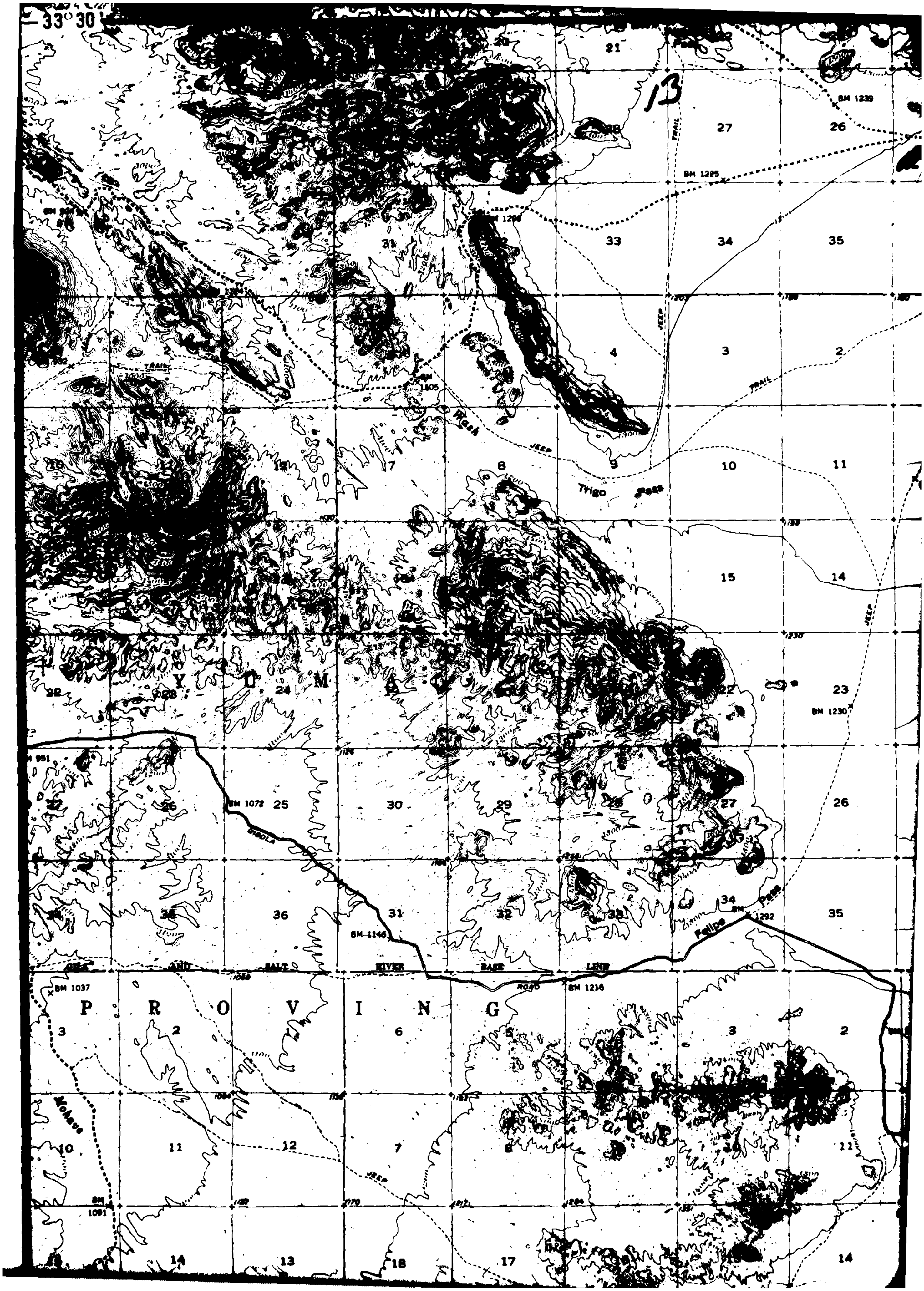
C-37
P-19
B-4
C-38
CS-38
S-8
R-8
C-39
CS-39
G-40
P-20
G-35B
G-42B
G-25A
G-42A
G-24A


C-64
CS-64
S-17
R-17
C-65
S-16
R-16
G-10A
G-9A
YUMA PROVING GROUND

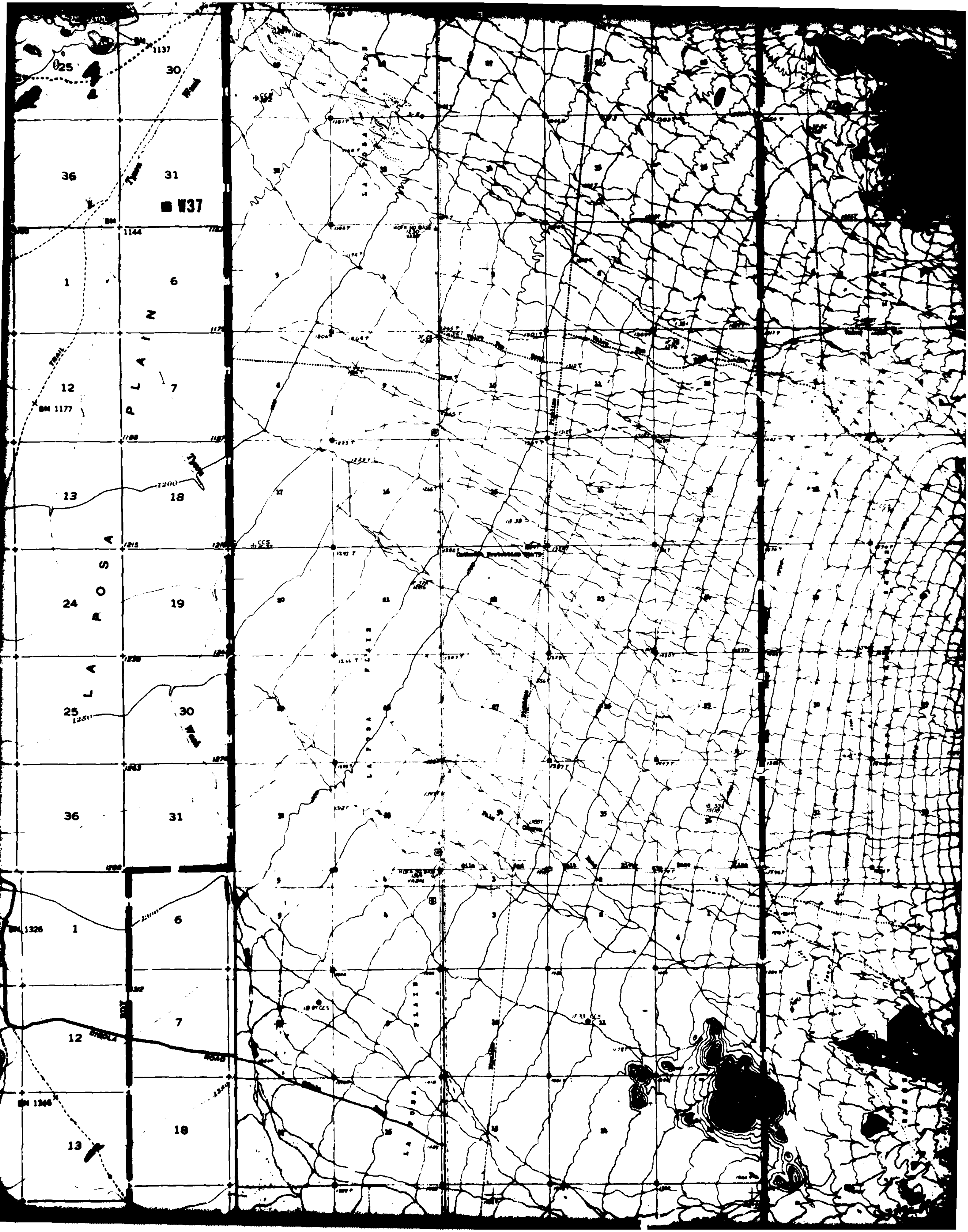

CS-60
C-62
CS-62
G-40A
C-63
F-25
G-14
C-67
F-26
C-65
C-66
CS-66
S-16
R-16
G-17A
C-57
CS-57
G-8A
S-12
R-12
S-13
R-13
LA PORA
30
19
1137
25



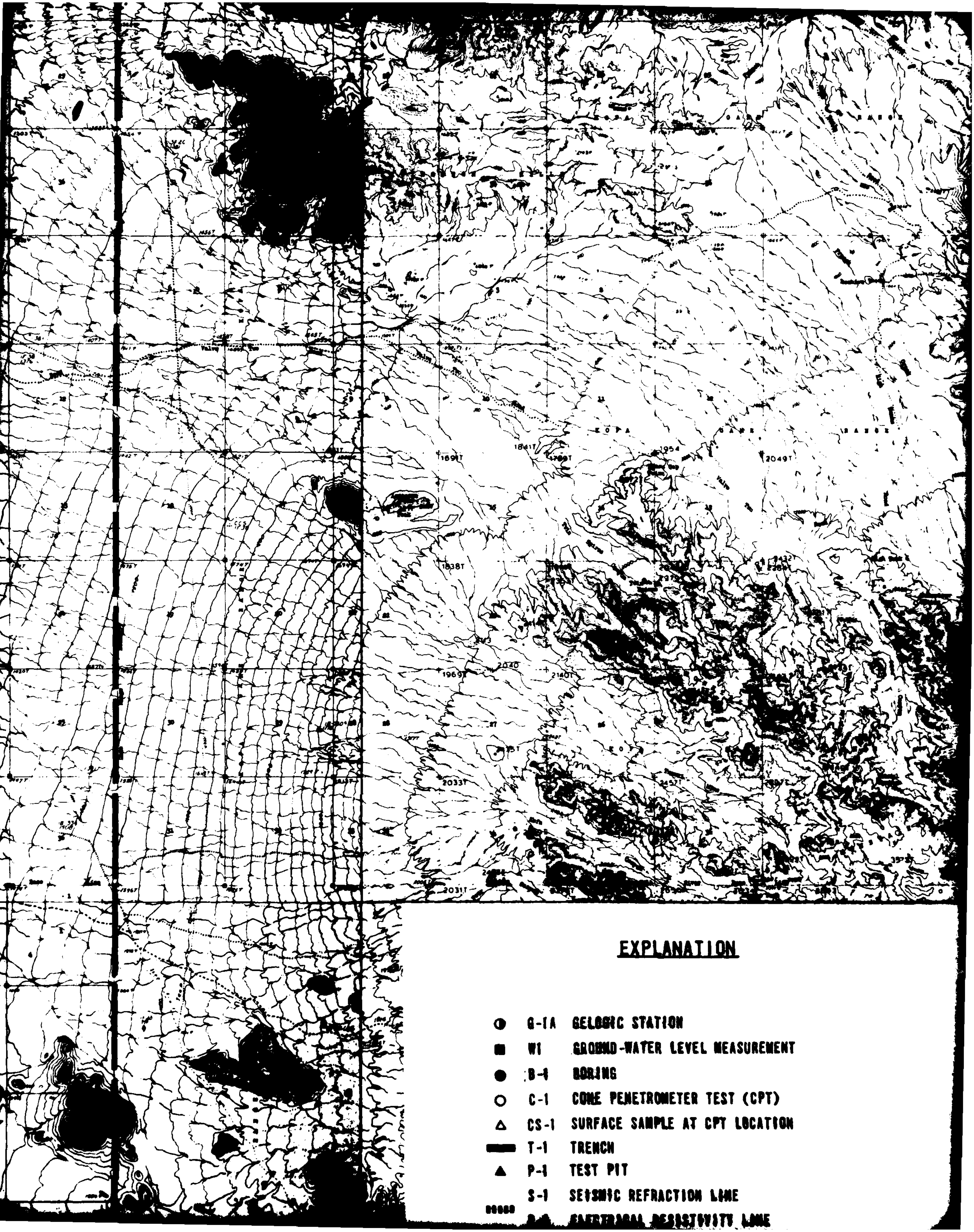
24A
S-13
W-13
W31
W33
W34
W35
W36
W38
33



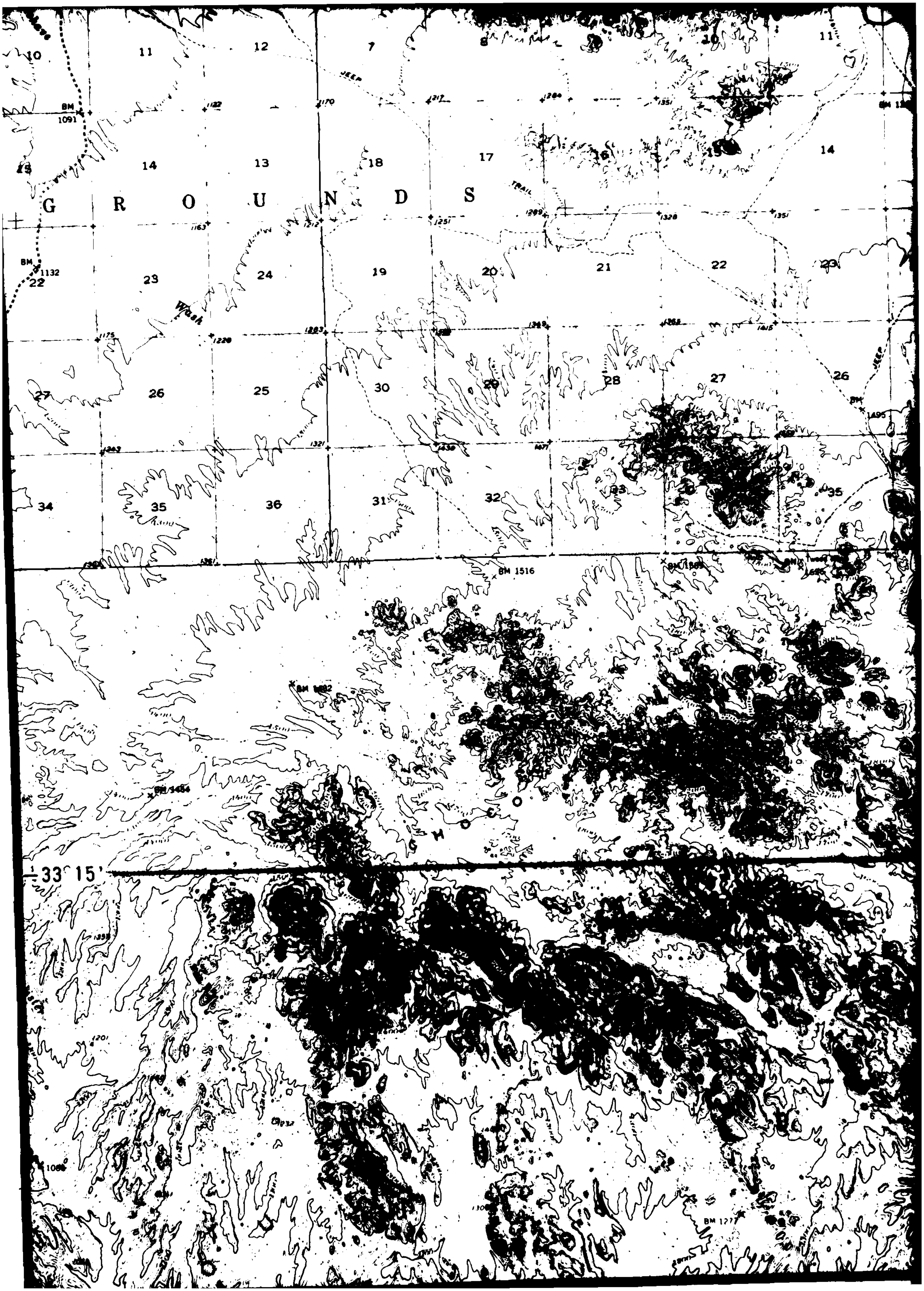
33° 30'
13
BM 1239
BM 1225
BM 1298
BM 1305
BM 1072
BM 1146
BM 1292
BM 1230
BM 1037
BM 1216
BM 1091
TRAIL
JEEP
Wash
Trigo Pass
Y U M A
P R O V I N G
GILA AND SALT RIVER BASE LINE
ROAD
Felipe Pass

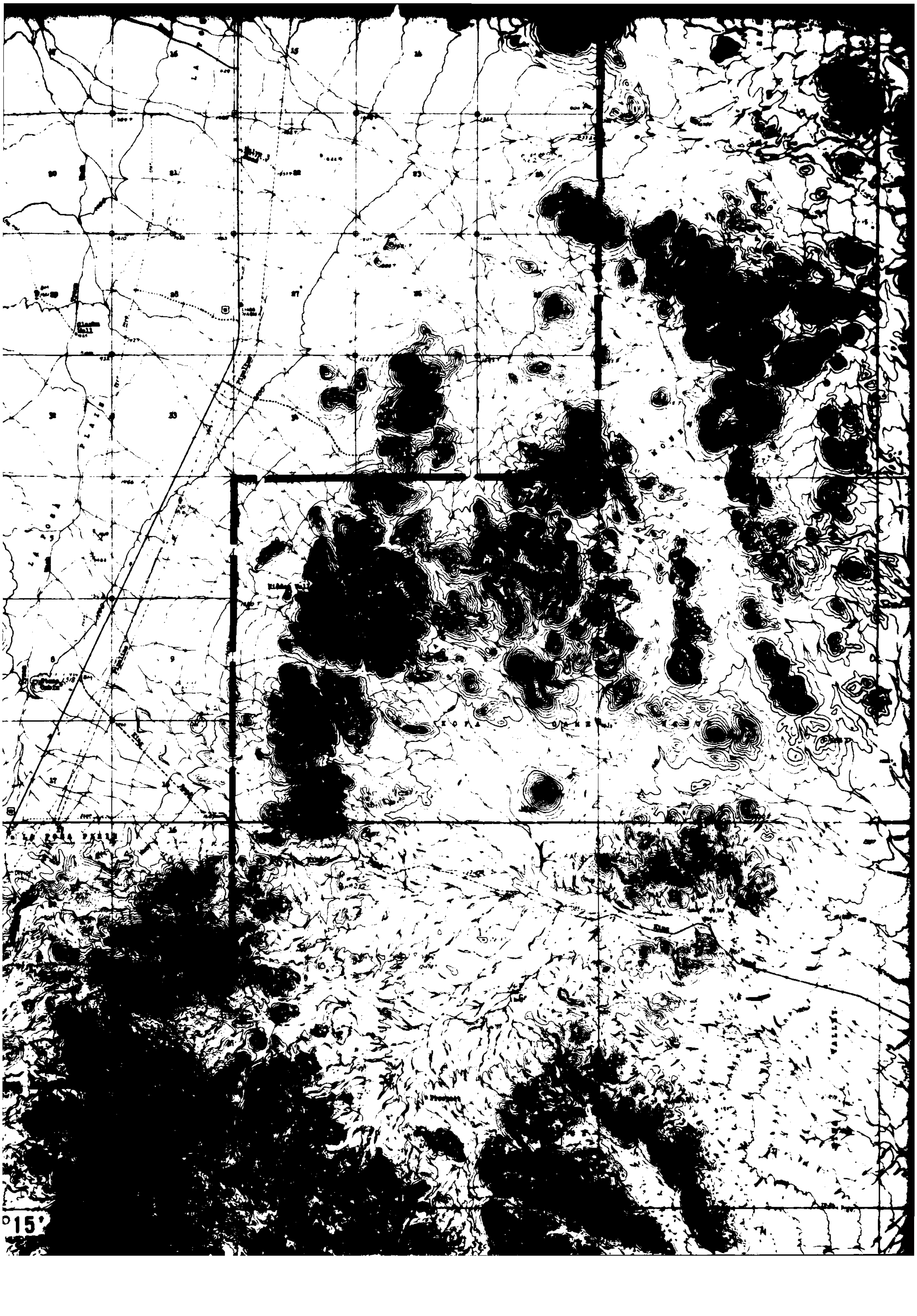


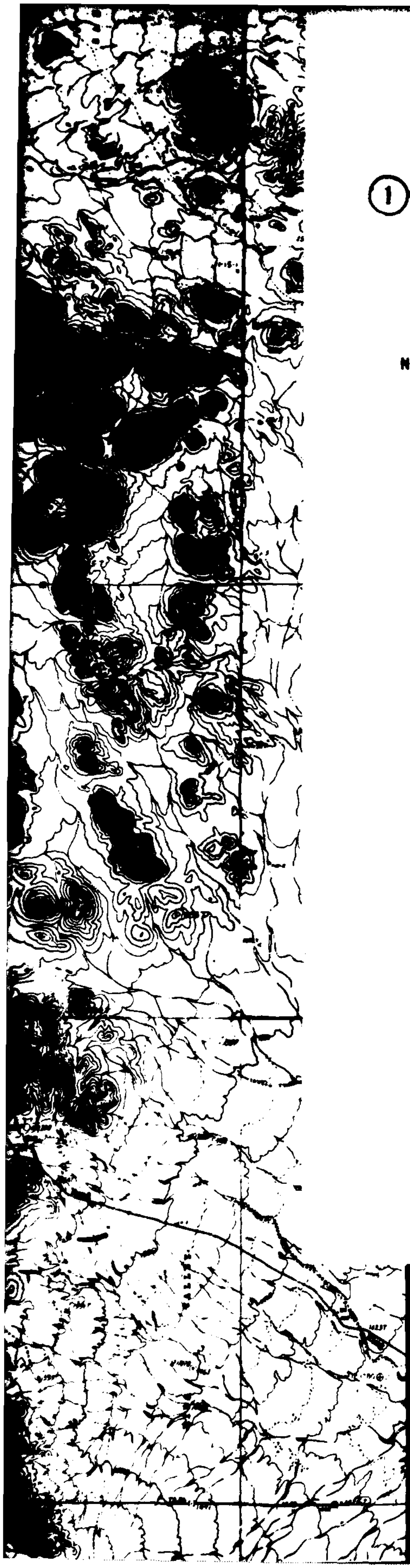
W37
BM 1137
BM 1144
BM 1177
BM 1326
BM 1346
LA POSA PLAIN
TRAIL
ROAD
CCS
1200
1250
25
30
36
31
1
6
12
7
13
18
24
19



EXPLANATION
G-1A GELOGIC STATION
W1 GROUND-WATER LEVEL MEASUREMENT
B-1 BORING
C-1 CONE PENETROMETER TEST (CPT)
CS-1 SURFACE SAMPLE AT CPT LOCATION
T-1 TRENCH
P-1 TEST PIT
S-1 SEISMIC REFRACTION LINE
1891T
1841T
1954
2049T
1838T
1969T
2040
2140T
2033T
2031T


GROUNDS
JEEP
TRAIL
Wash
BM 1091
BM 1132
BM 1516
BM 1454
33° 15'


15'



T-1 TRENCH

P-1 TEST PIT

S-1 SEISMIC REFRACTION LINE

R-1 ELECTRICAL RESISTIVITY LINE

1 — 1' ACTIVITY LINE

NOTE: Where multiple activities were performed at the same location, the correct location is designated by either (1) the boring symbol or (2) the CPT symbol, if no boring was drilled.

LOCATION MAP

SCALE 1:62,500

0 1 2 3
STATUTE MILES

0 1 2 3
NAUTICAL MILES

33°15'

0 5,000 10,000
FEET

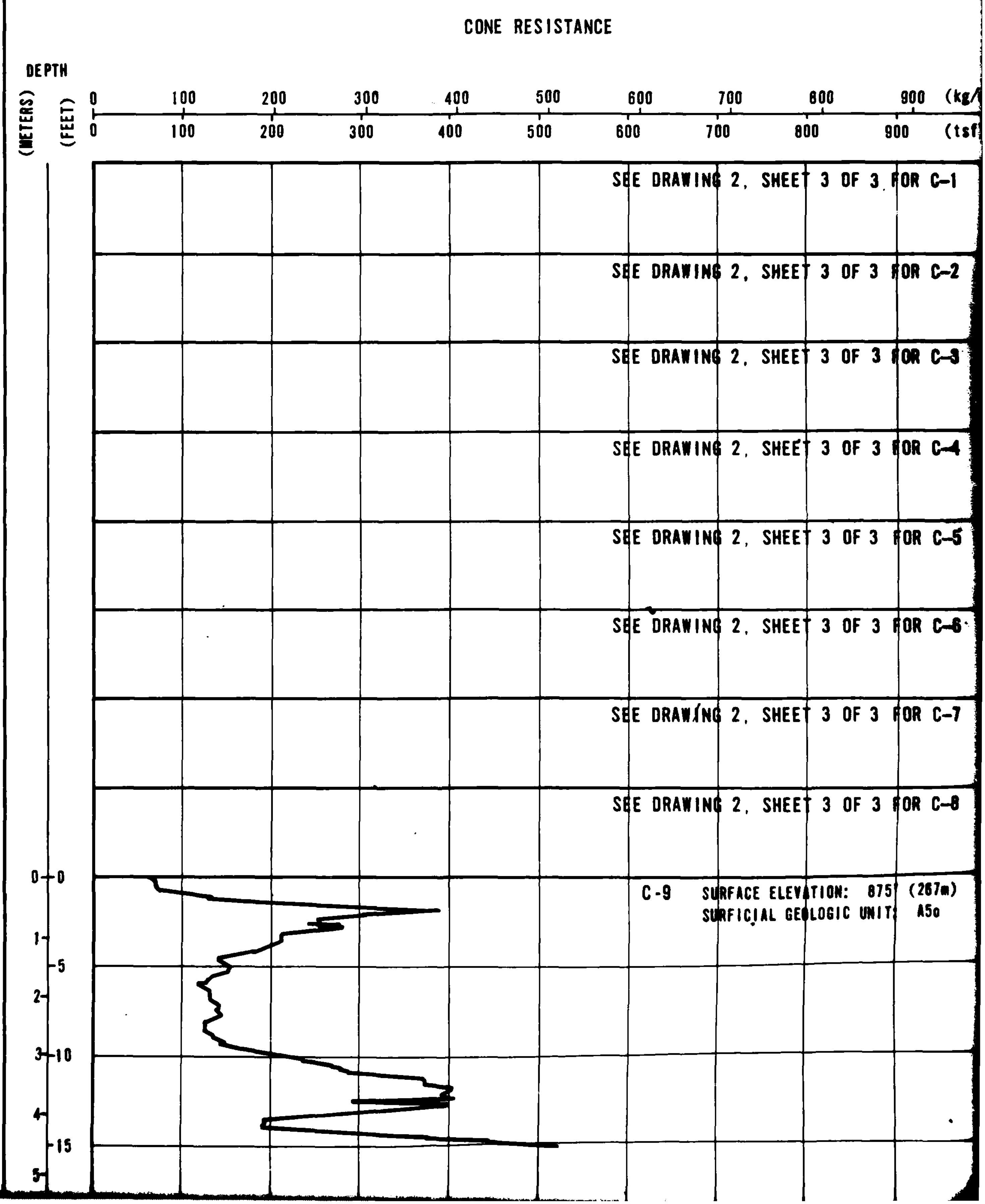
0 1 2 3
KILOMETERS

ACTIVITY LOCATION MAP
LA POSA CDP, ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

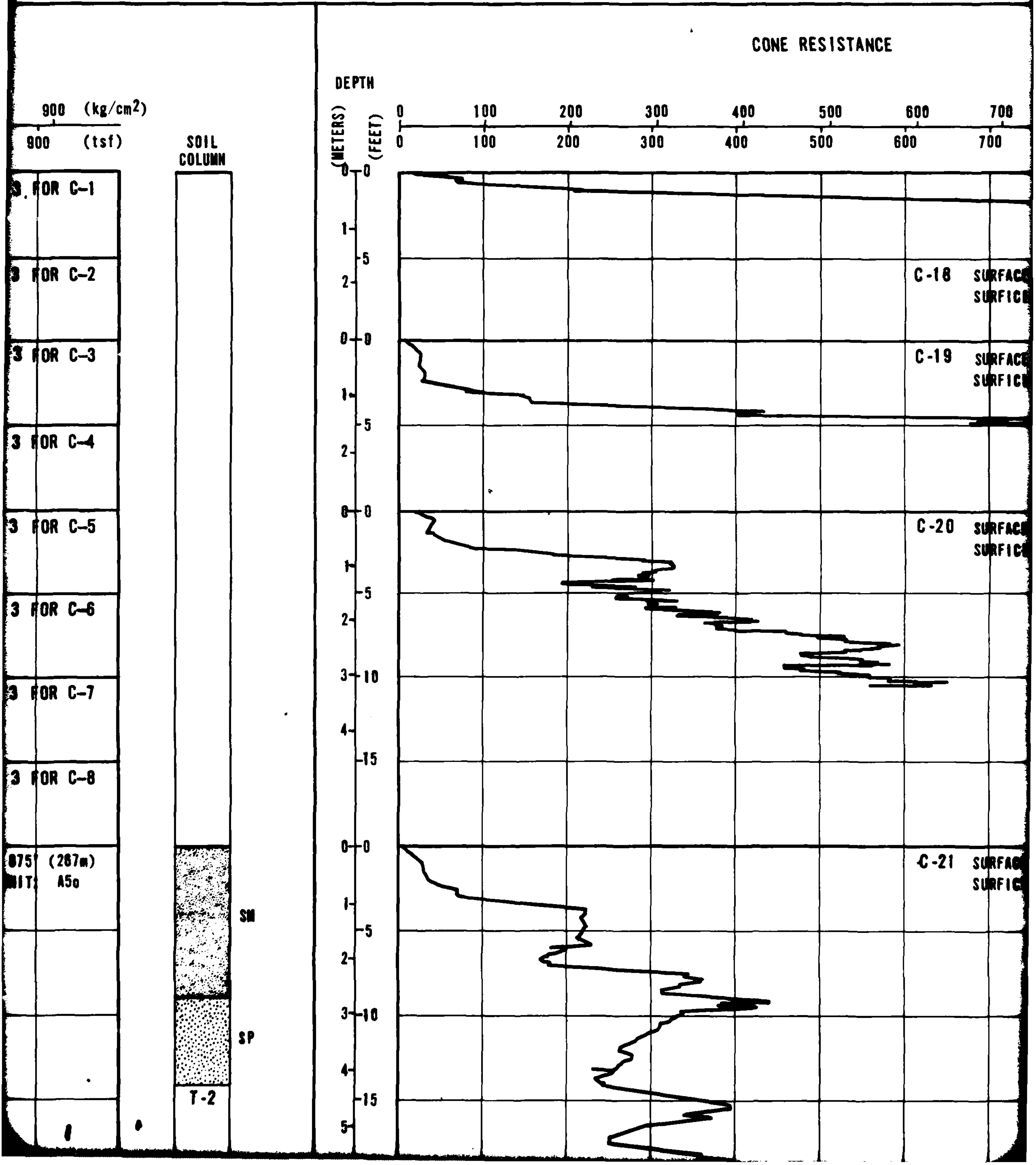
DRAWING
1

FUGRO NATIONAL, INC.

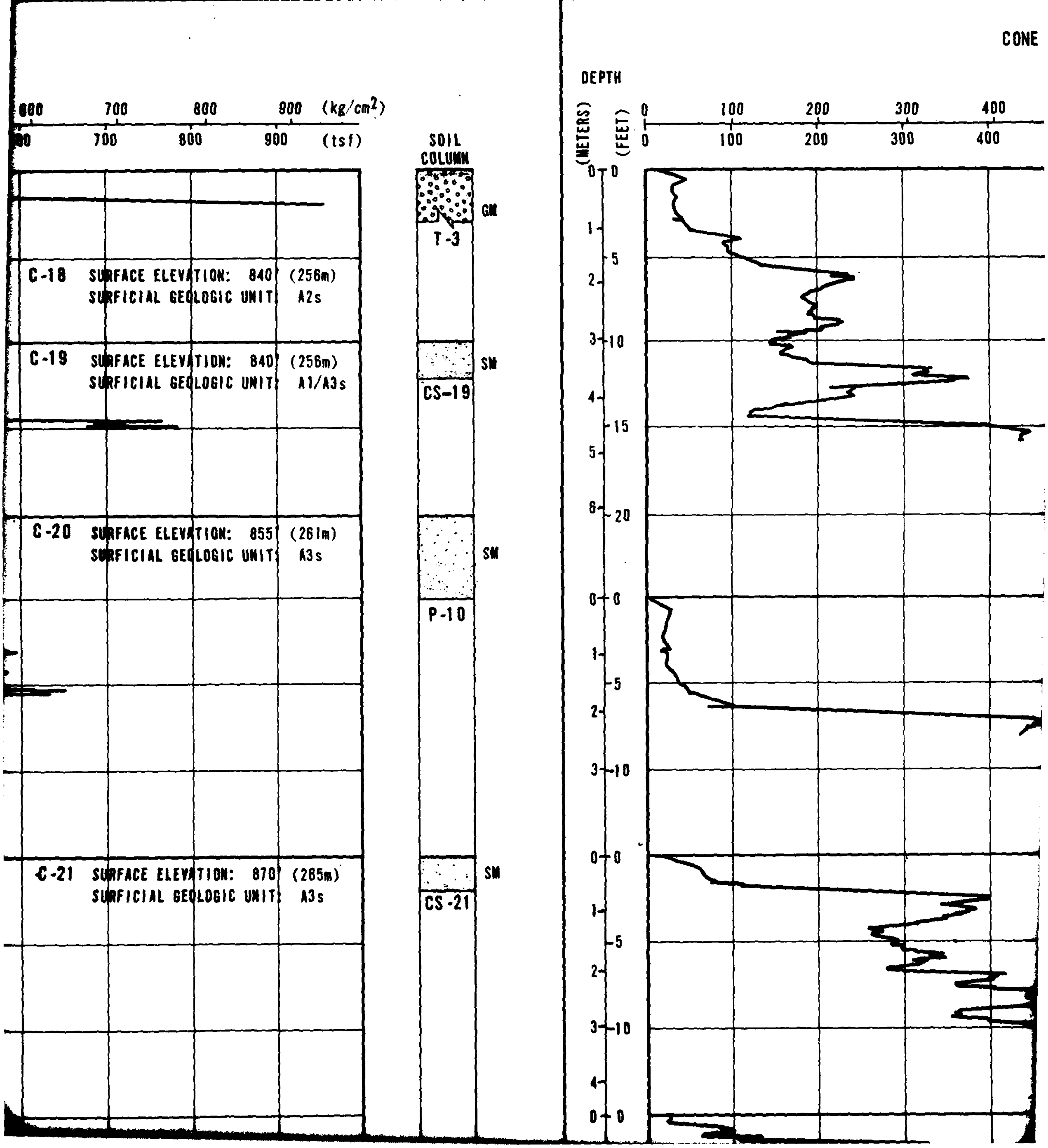

CONE RESISTANCE
DEPTH
(METERS)
(FEET)
0 100 200 300 400 500 600 700 800 900 (kg/
0 100 200 300 400 500 600 700 800 900 (tsf
SEE DRAWING 2, SHEET 3 OF 3 FOR C-1
SEE DRAWING 2, SHEET 3 OF 3 FOR C-2
SEE DRAWING 2, SHEET 3 OF 3 FOR C-3
SEE DRAWING 2, SHEET 3 OF 3 FOR C-4
SEE DRAWING 2, SHEET 3 OF 3 FOR C-5
SEE DRAWING 2, SHEET 3 OF 3 FOR C-6
SEE DRAWING 2, SHEET 3 OF 3 FOR C-7
SEE DRAWING 2, SHEET 3 OF 3 FOR C-8
C-9 SURFACE ELEVATION: 875' (267m)
SURFICIAL GEOLOGIC UNIT: A5o
0 1 2 3 4 5
0 5 10 15

1

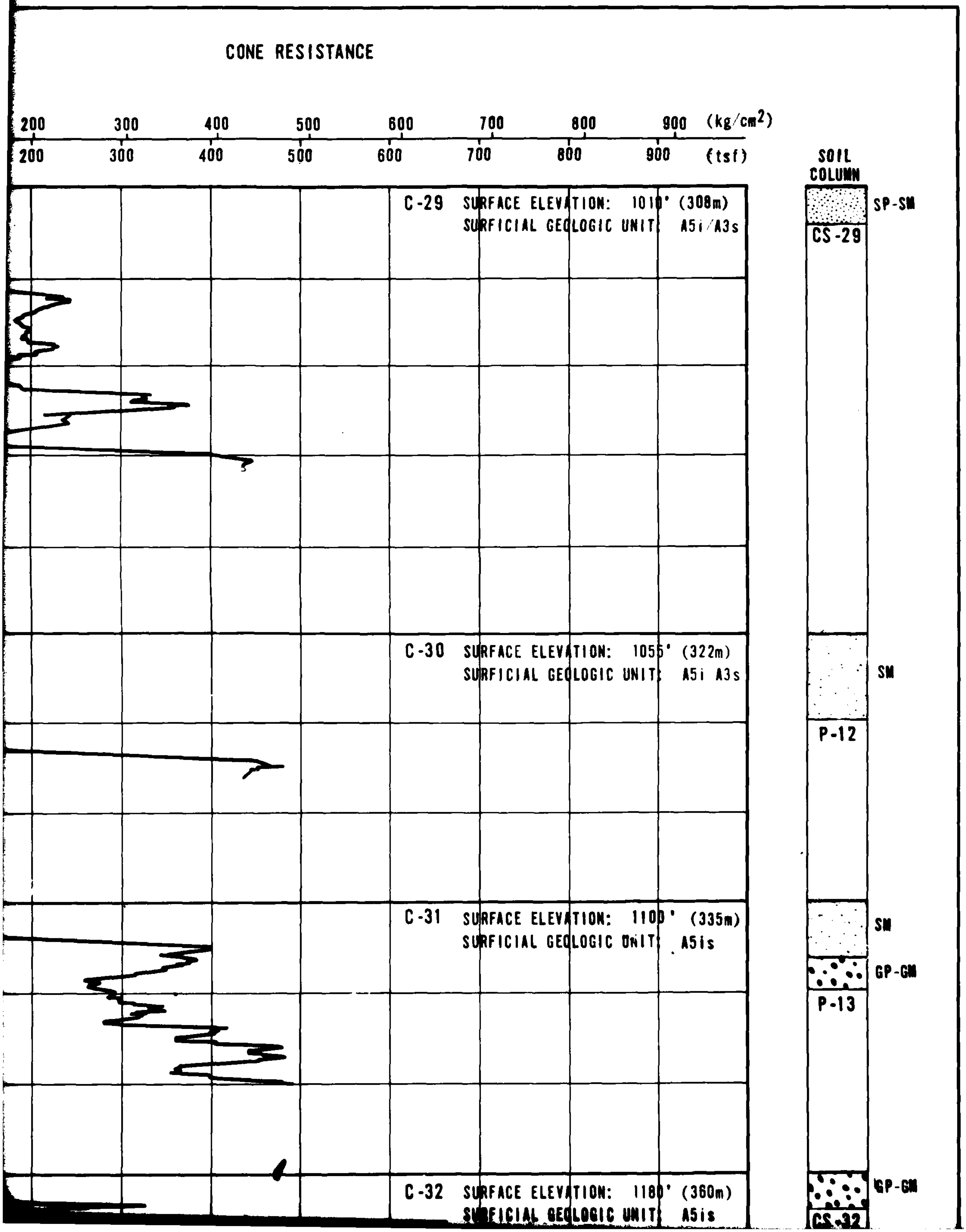
2.


CONE RESISTANCE
DEPTH
(METERS)
(FEET)
900 (kg/cm2)
900 (tsf)
SOIL COLUMN
0
100
200
300
400
500
600
700
3 FOR C-1
3 FOR C-2
3 FOR C-3
3 FOR C-4
3 FOR C-5
3 FOR C-6
3 FOR C-7
3 FOR C-8
875' (267m)
UNIT: A5a
SM
SP
T-2
C-18 SURFACE
SURFICI
C-19 SURFACE
SURFICI
C-20 SURFACE
SURFICI
C-21 SURFACE
SURFICI

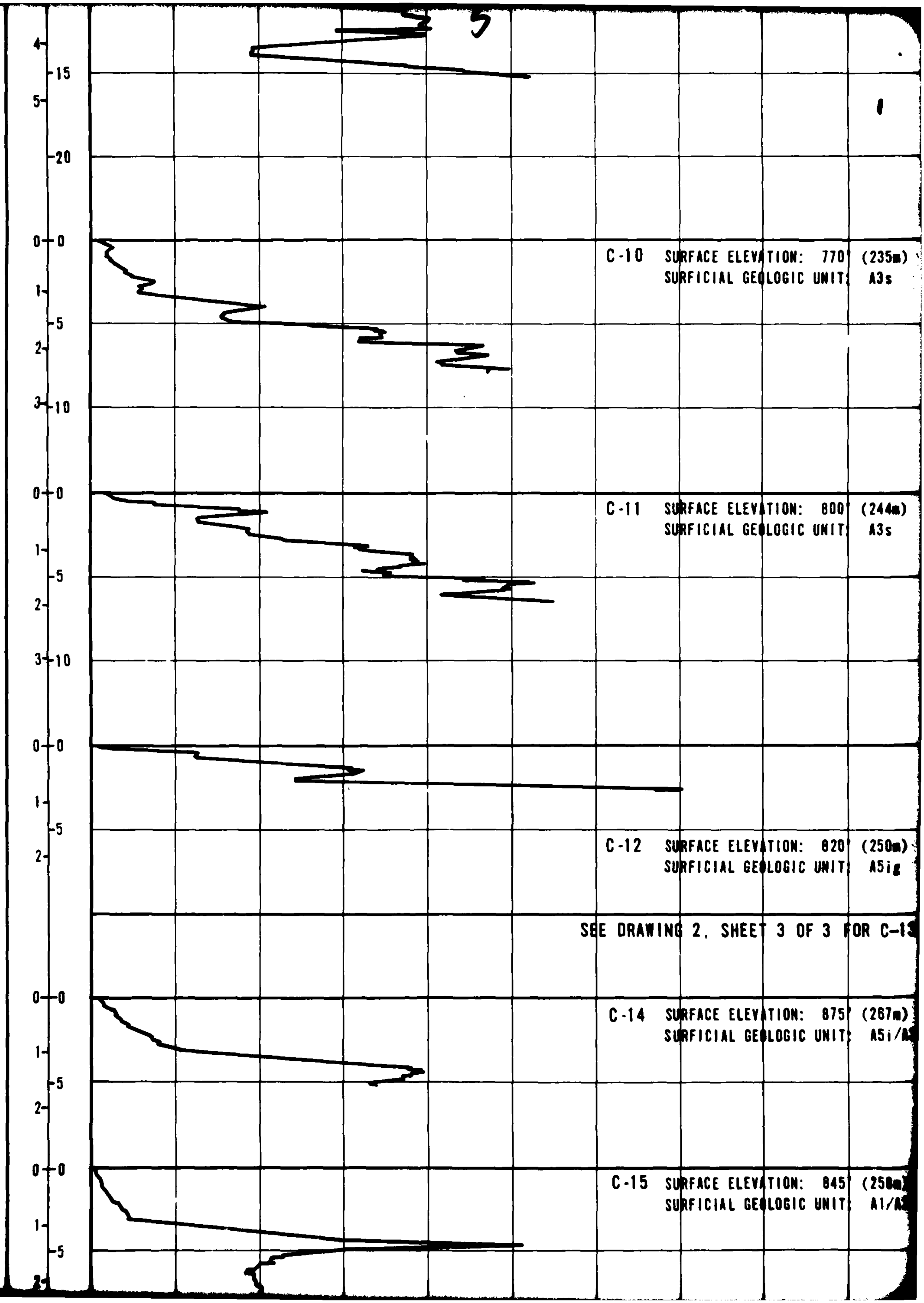
3

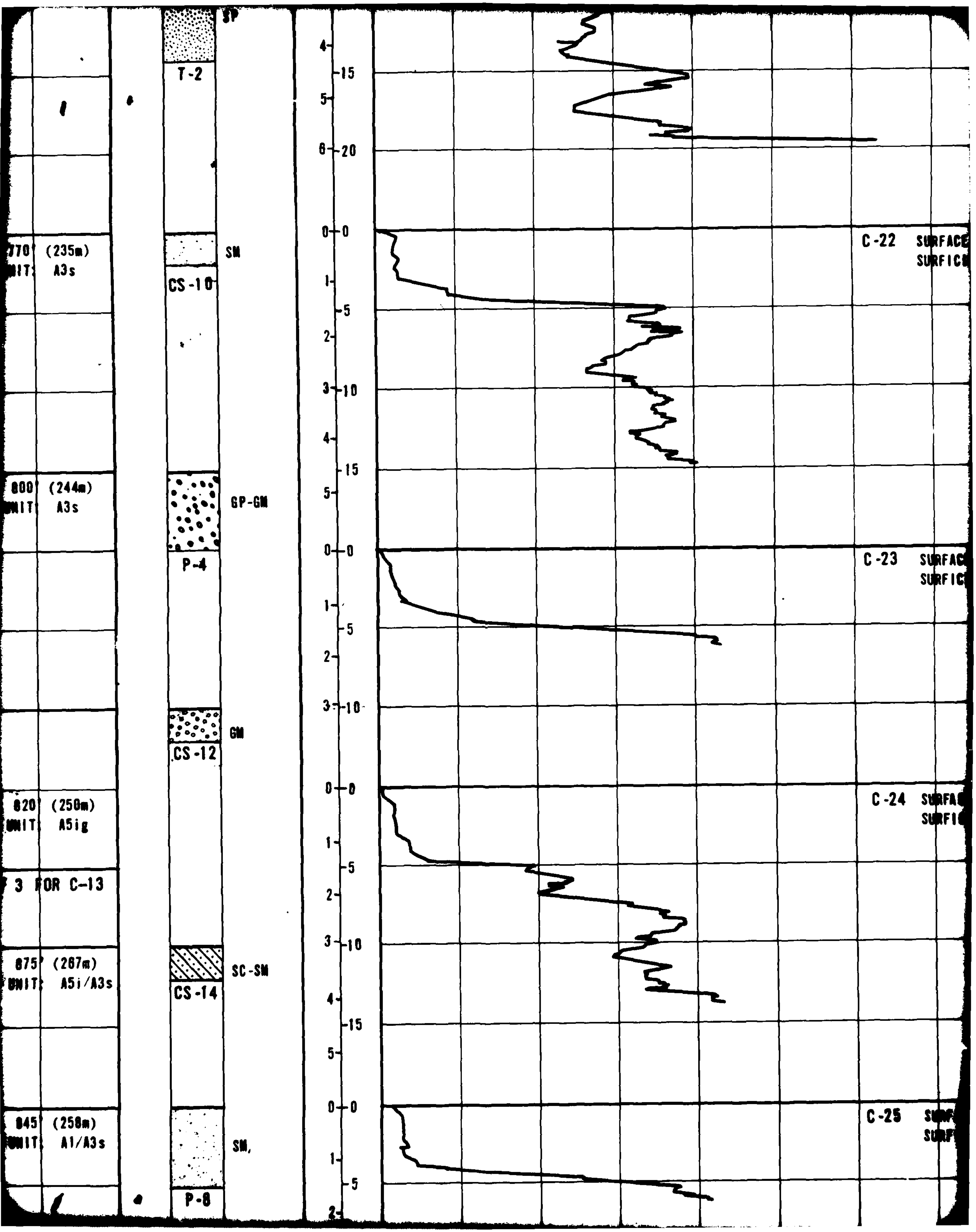

CONE
DEPTH
(METERS)
(FEET)
600 700 800 900 (kg/cm²)
700 800 900 (tsf)
0 100 200 300 400
SOIL COLUMN
GM
T-3
C-18 SURFACE ELEVATION: 840' (256m)
SURFICIAL GEOLOGIC UNIT: A2s
C-19 SURFACE ELEVATION: 840' (256m)
SURFICIAL GEOLOGIC UNIT: A1/A3s
SM
CS-19
C-20 SURFACE ELEVATION: 855' (261m)
SURFICIAL GEOLOGIC UNIT: A3s
SM
P-10
C-21 SURFACE ELEVATION: 870' (265m)
SURFICIAL GEOLOGIC UNIT: A3s
SM
CS-21

4

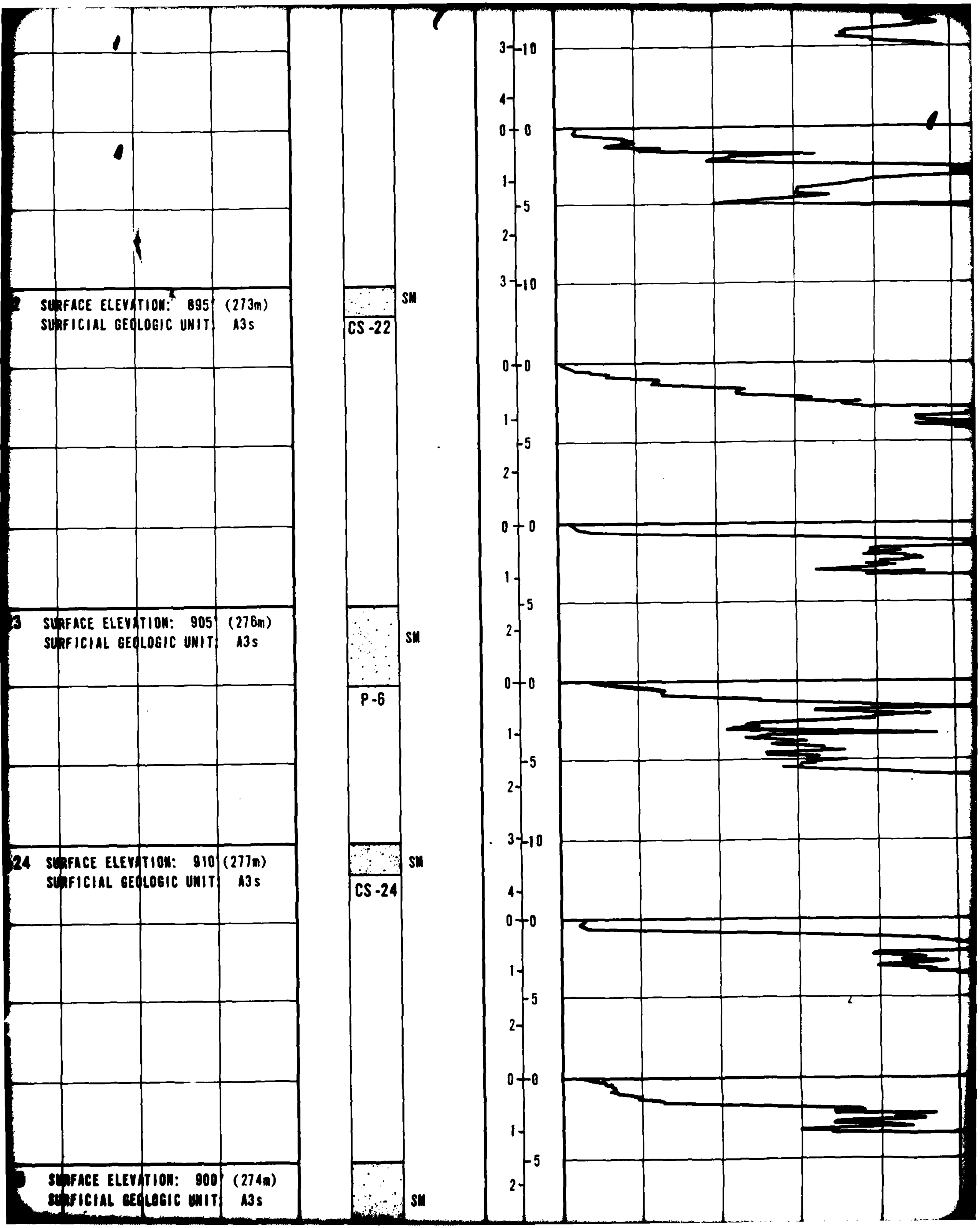


CONE RESISTANCE
200 300 400 500 600 700 800 900 (kg/cm2)
200 300 400 500 600 700 800 900 (tsf)
SOIL COLUMN
C-29 SURFACE ELEVATION: 1010' (308m)
SURFICIAL GEOLOGIC UNIT: A5i/A3s
SP-SM
CS-29
C-30 SURFACE ELEVATION: 1055' (322m)
SURFICIAL GEOLOGIC UNIT: A5i A3s
SM
P-12
C-31 SURFACE ELEVATION: 1100' (335m)
SURFICIAL GEOLOGIC UNIT: A5is
SM
GP-GM
P-13
C-32 SURFACE ELEVATION: 1180' (360m)
SURFICIAL GEOLOGIC UNIT: A5is
GP-GM
CS-32

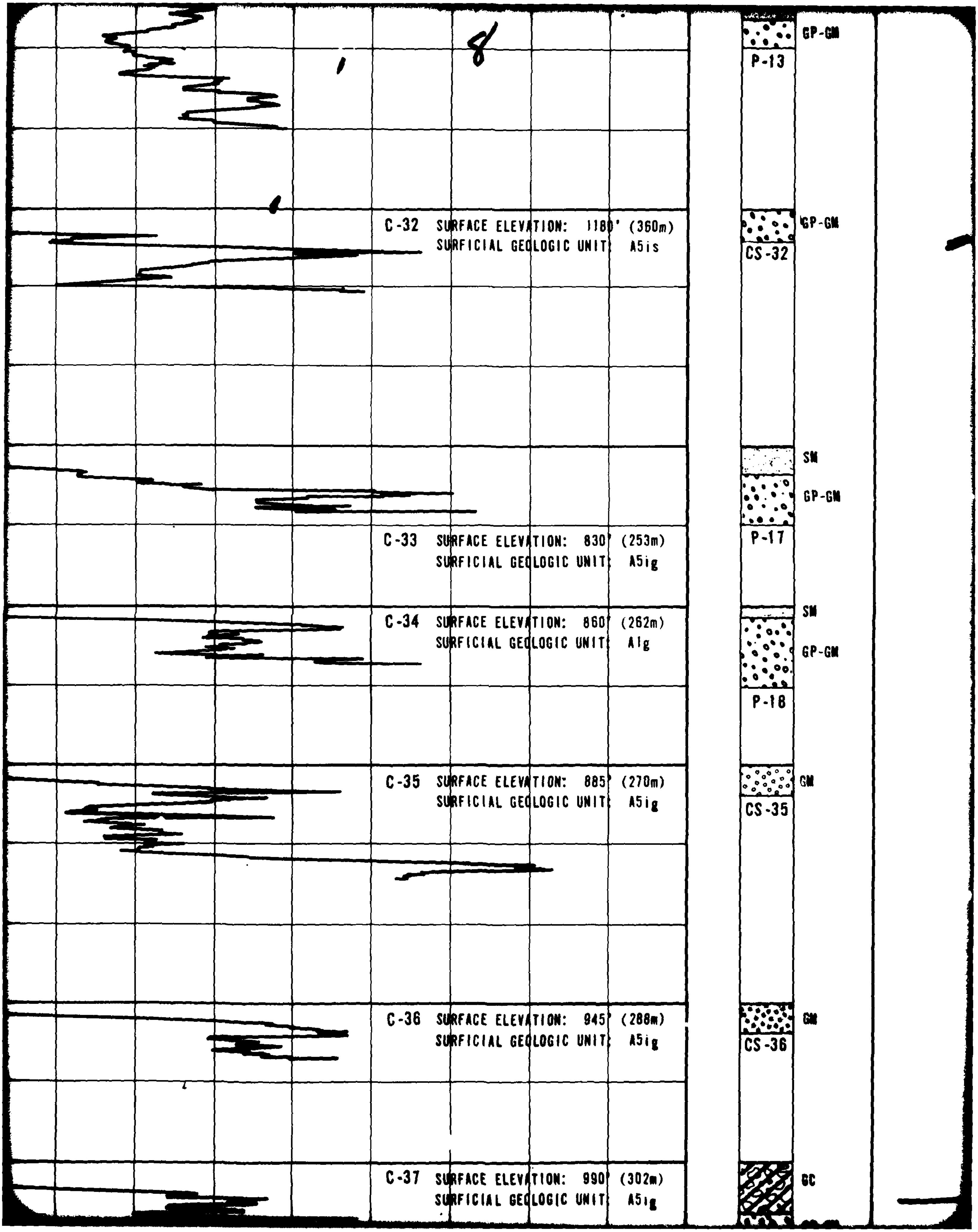

5
C-10 SURFACE ELEVATION: 770' (235m)
SURFICIAL GEOLOGIC UNIT: A3s
C-11 SURFACE ELEVATION: 800' (244m)
SURFICIAL GEOLOGIC UNIT: A3s
C-12 SURFACE ELEVATION: 820' (250m)
SURFICIAL GEOLOGIC UNIT: A5ig
SEE DRAWING 2, SHEET 3 OF 3 FOR C-13
C-14 SURFACE ELEVATION: 875' (267m)
SURFICIAL GEOLOGIC UNIT: A5i/A
C-15 SURFACE ELEVATION: 845' (258m)
SURFICIAL GEOLOGIC UNIT: A1/A

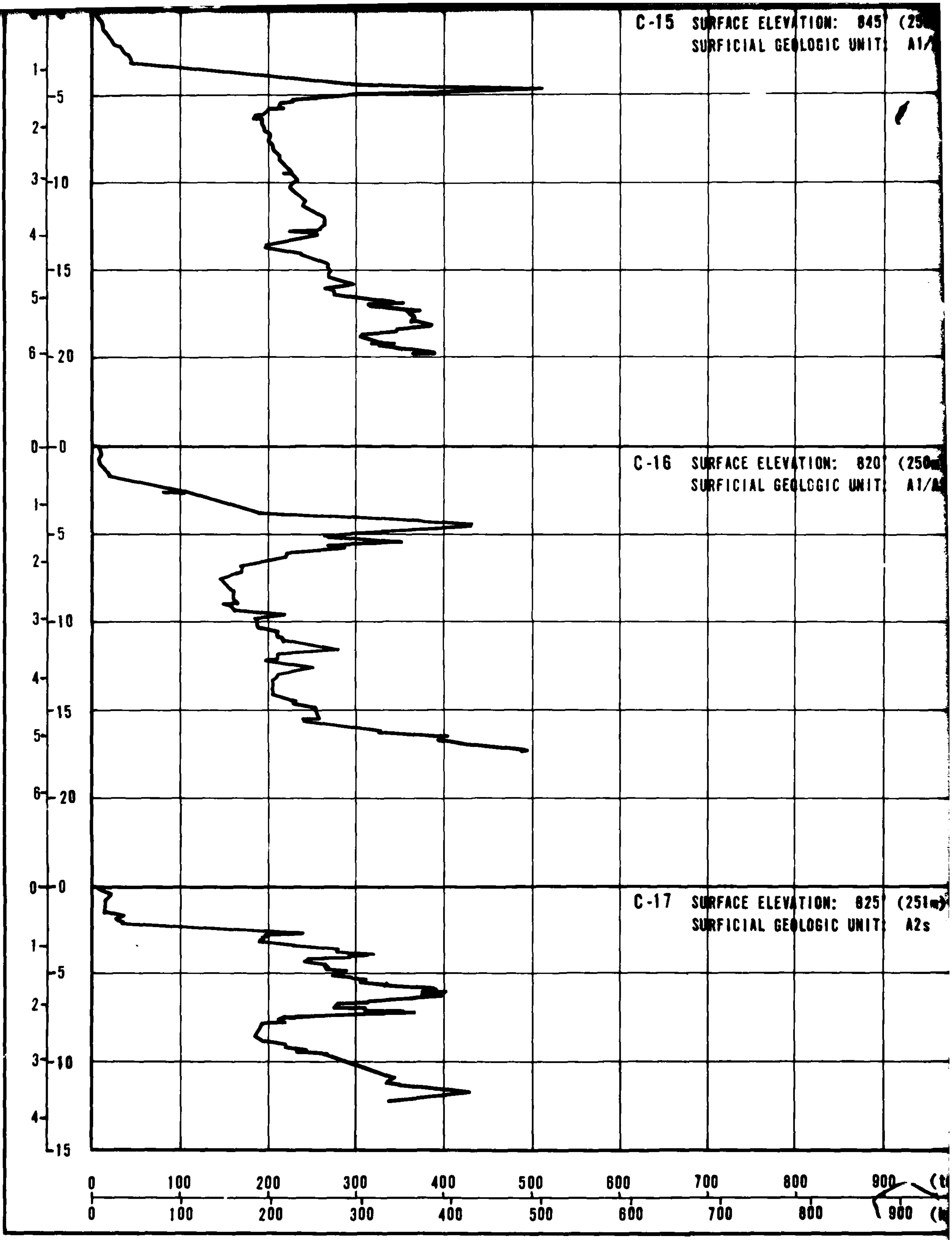


770' (235m)
UNIT: A3s
800' (244m)
UNIT: A3s
820' (250m)
UNIT: A5ig
3 FOR C-13
875' (267m)
UNIT: A5i/A3s
845' (258m)
UNIT: A1/A3s
SP
T-2
SM
CS-10
GP-GM
P-4
GM
CS-12
SC-SM
CS-14
SM,
P-8
C-22
C-23
C-24
C-25



2 SURFACE ELEVATION: 895' (273m)
SURFICIAL GEOLOGIC UNIT: A3s
SM
CS-22
3 SURFACE ELEVATION: 905' (276m)
SURFICIAL GEOLOGIC UNIT: A3s
SM
P-6
24 SURFACE ELEVATION: 910' (277m)
SURFICIAL GEOLOGIC UNIT: A3s
SM
CS-24
SURFACE ELEVATION: 900' (274m)
SURFICIAL GEOLOGIC UNIT: A3s
SM


8
GP-GM
P-13
C-32 SURFACE ELEVATION: 1180' (360m)
SURFICIAL GEOLOGIC UNIT: A5is
GP-GM
CS-32
SM
GP-GM
C-33 SURFACE ELEVATION: 830' (253m)
SURFICIAL GEOLOGIC UNIT: A5ig
P-17
C-34 SURFACE ELEVATION: 860' (262m)
SURFICIAL GEOLOGIC UNIT: A1g
SM
GP-GM
P-18
C-35 SURFACE ELEVATION: 885' (270m)
SURFICIAL GEOLOGIC UNIT: A5ig
GM
CS-35
C-36 SURFACE ELEVATION: 945' (288m)
SURFICIAL GEOLOGIC UNIT: A5ig
GM
CS-36
C-37 SURFACE ELEVATION: 990' (302m)
SURFICIAL GEOLOGIC UNIT: A5ig
GC

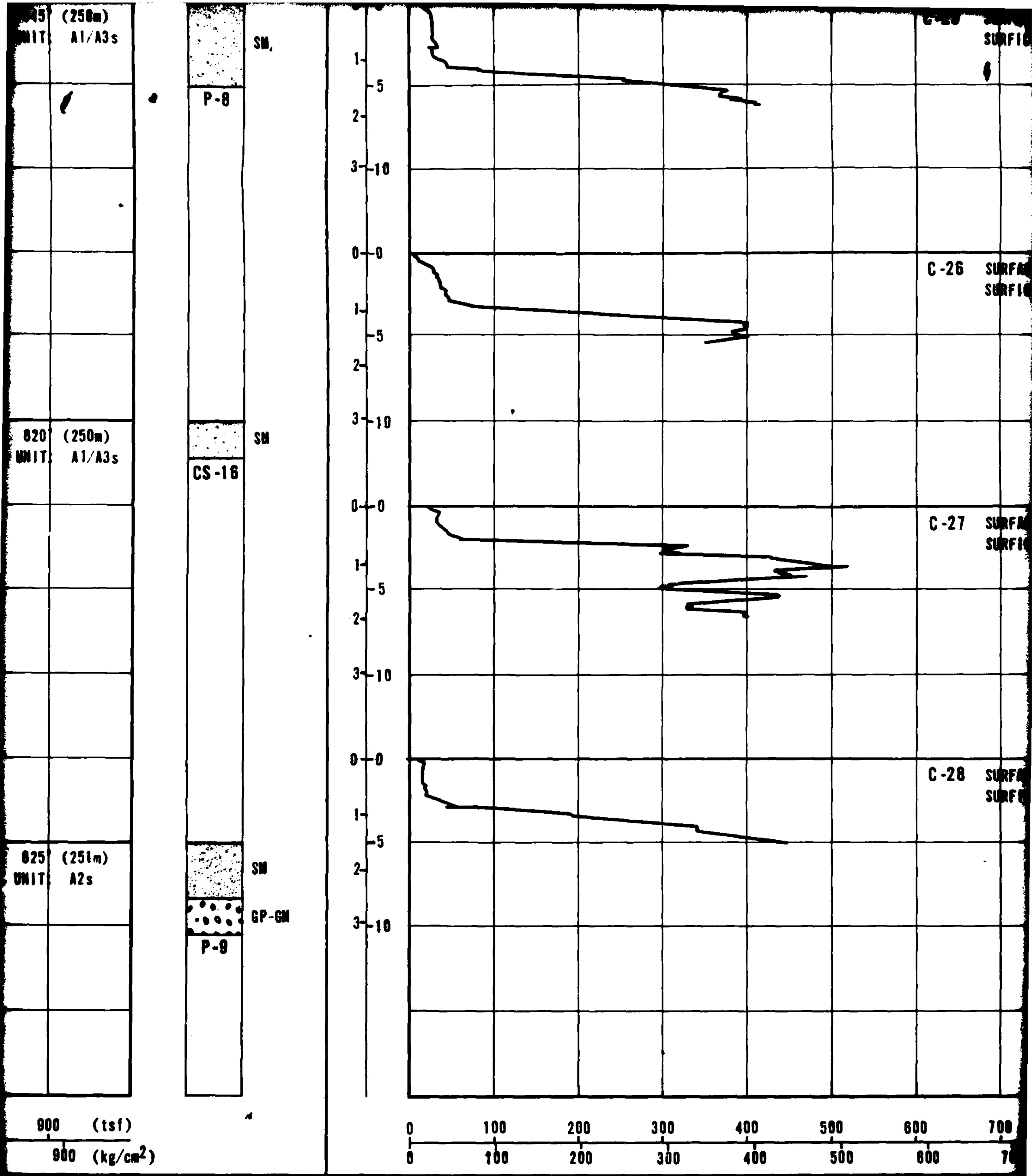


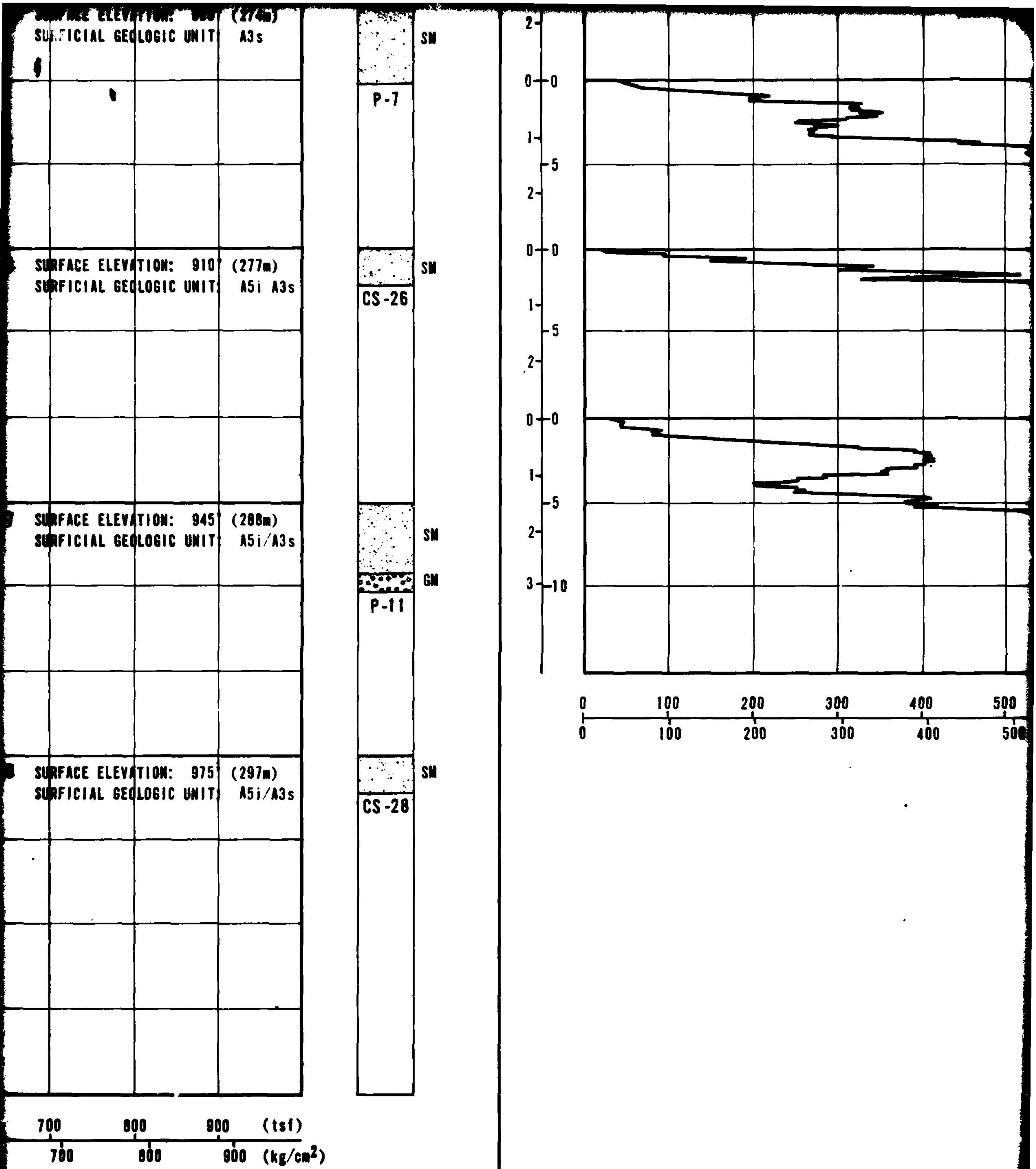
APPROVED BY

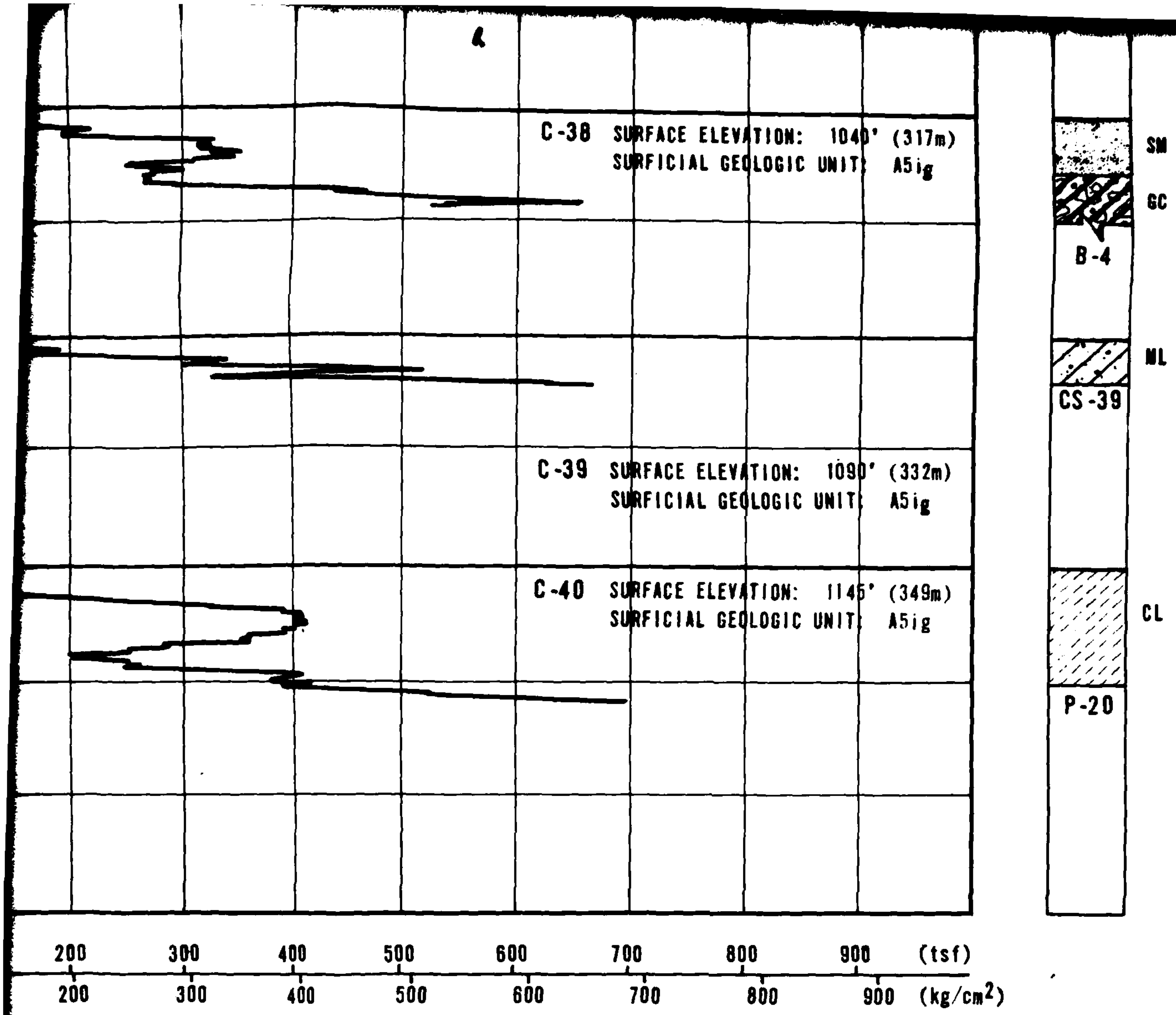
CHECKED BY

10 AUG 79

9


(250m)
UNIT: A1/A3s
SM
P-8
820' (250m)
UNIT: A1/A3s
SM
CS-16
825' (251m)
UNIT: A2s
SM
GP-GM
P-9
C-26
C-27
C-28
SURF
900 (tsf)
900 (kg/cm2)
0
100
200
300
400
500
600
700


SURFICIAL GEOLOGIC UNIT: A3s
SM
P-7
SURFACE ELEVATION: 910' (277m)
SURFICIAL GEOLOGIC UNIT: A5i A3s
SM
CS-26
SURFACE ELEVATION: 945' (288m)
SURFICIAL GEOLOGIC UNIT: A5i/A3s
SM
GM
P-11
SURFACE ELEVATION: 975' (297m)
SURFICIAL GEOLOGIC UNIT: A5i/A3s
SM
CS-28
700 800 900 (tsf)
700 800 900 (kg/cm2)
0 100 200 300 400 500



CONE PENETROMETER TEST RESULTS
VERIFICATION SITE
LA POSA CDP, ARIZONA

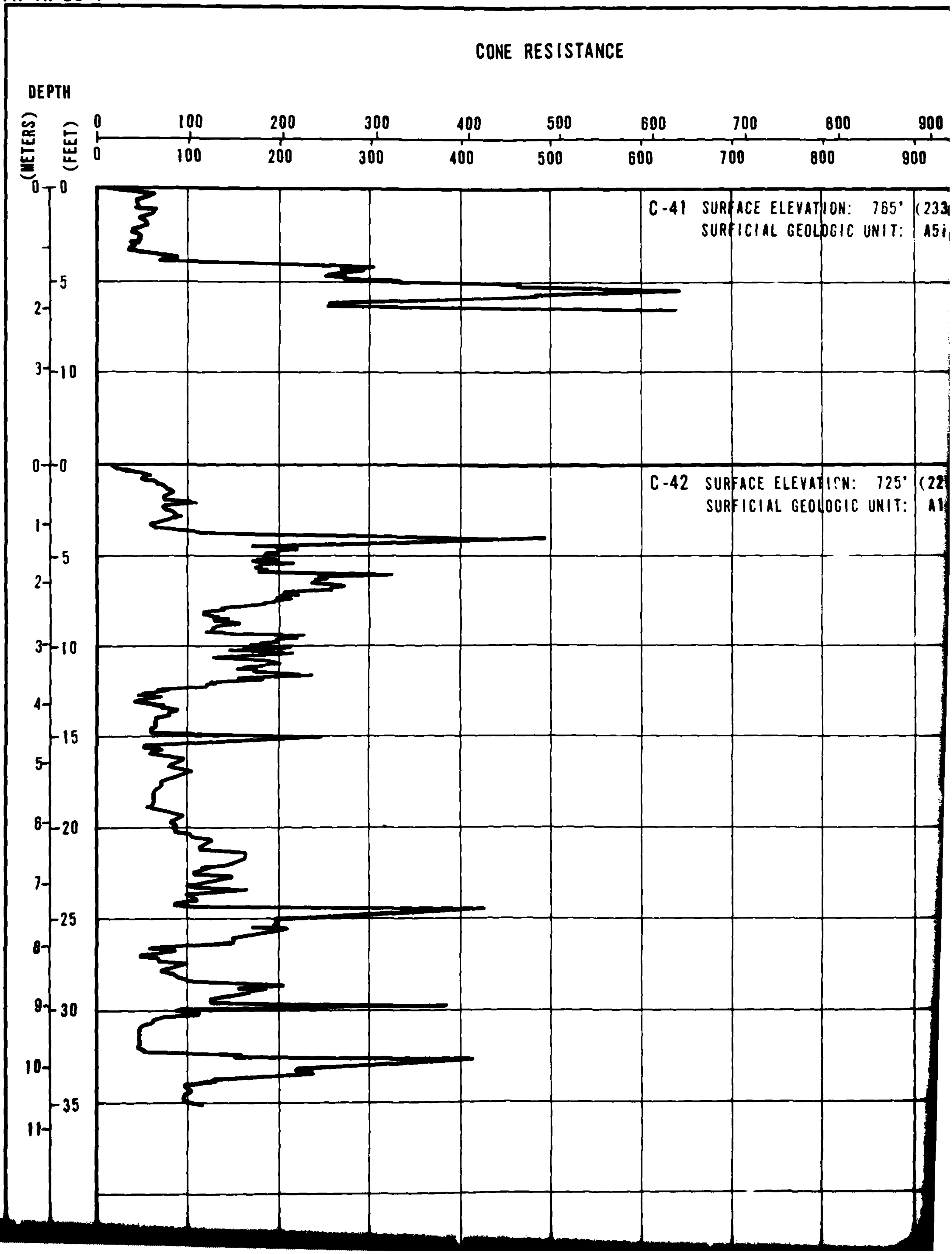
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING
2
1 OF 3

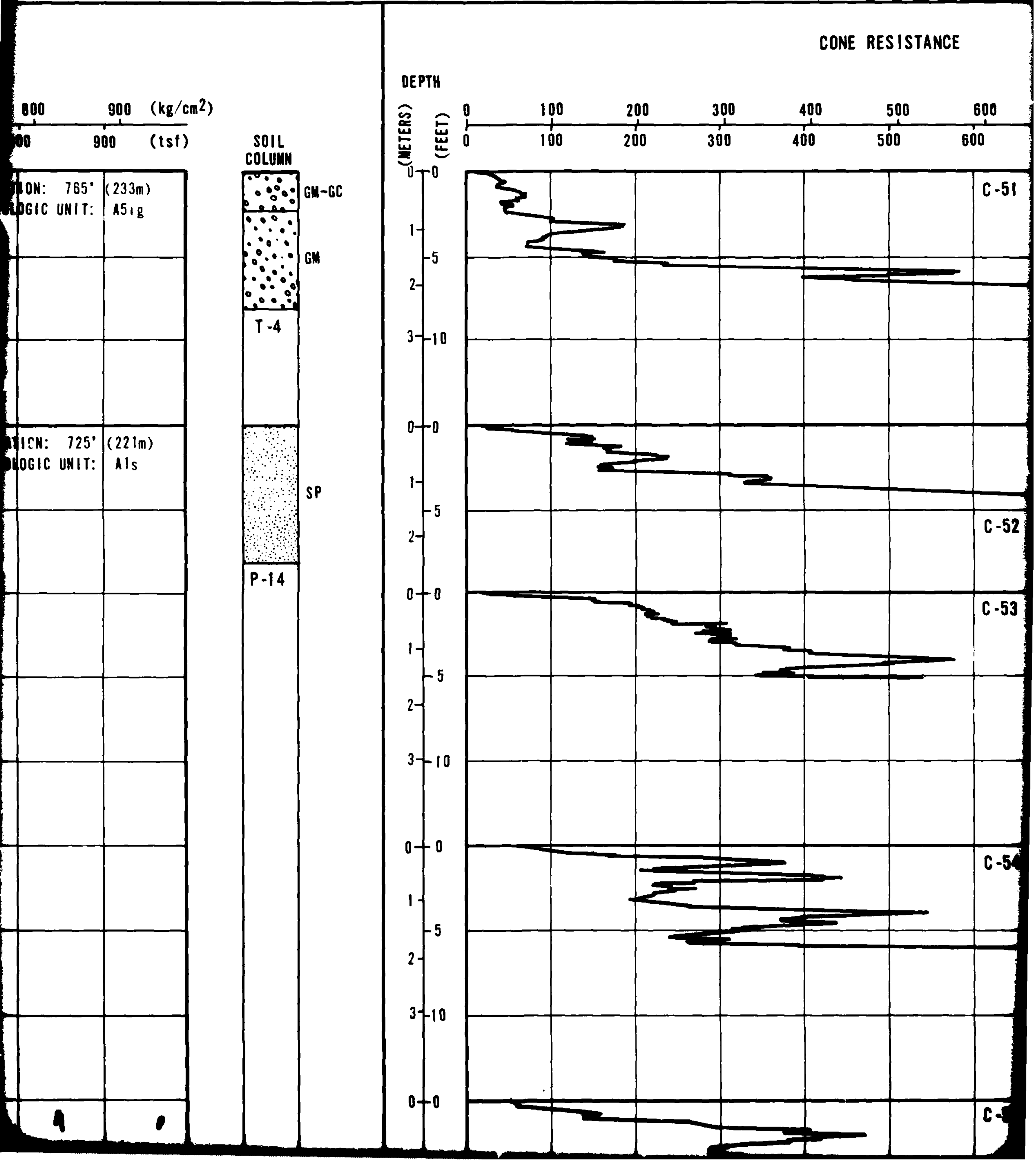
FUGRO NATIONAL, INC.

12

FN-TR-28-1

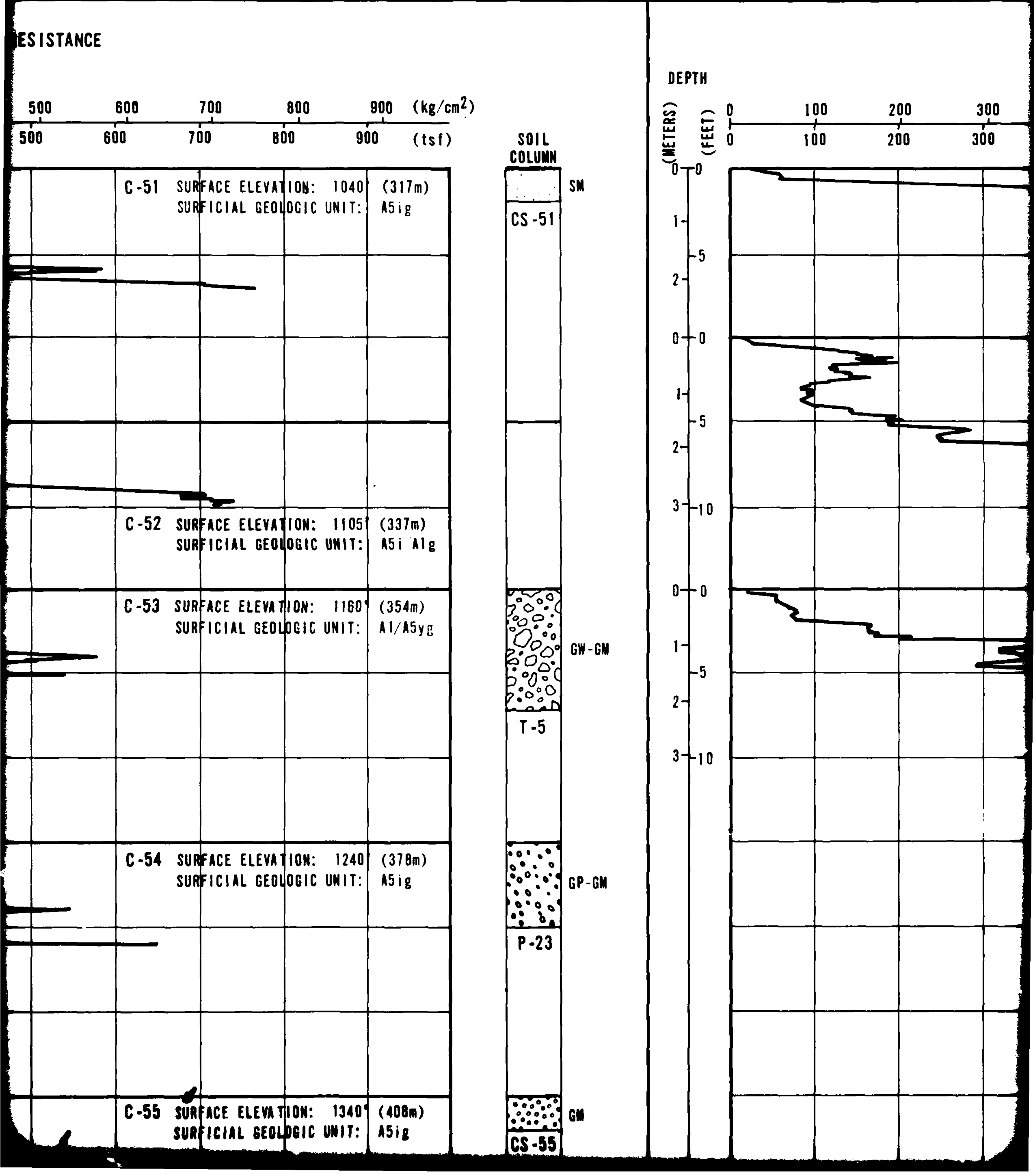

CONE RESISTANCE
DEPTH
(METERS)
(FEET)
0 100 200 300 400 500 600 700 800 900
0 100 200 300 400 500 600 700 800 900
C-41 SURFACE ELEVATION: 765' (233
SURFICIAL GEOLOGIC UNIT: A5i
C-42 SURFACE ELEVATION: 725' (22
SURFICIAL GEOLOGIC UNIT: A1
0 1 2 3 4 5 6 7 8 9 10 11
0 5 10 15 20 25 30 35

1 2 1



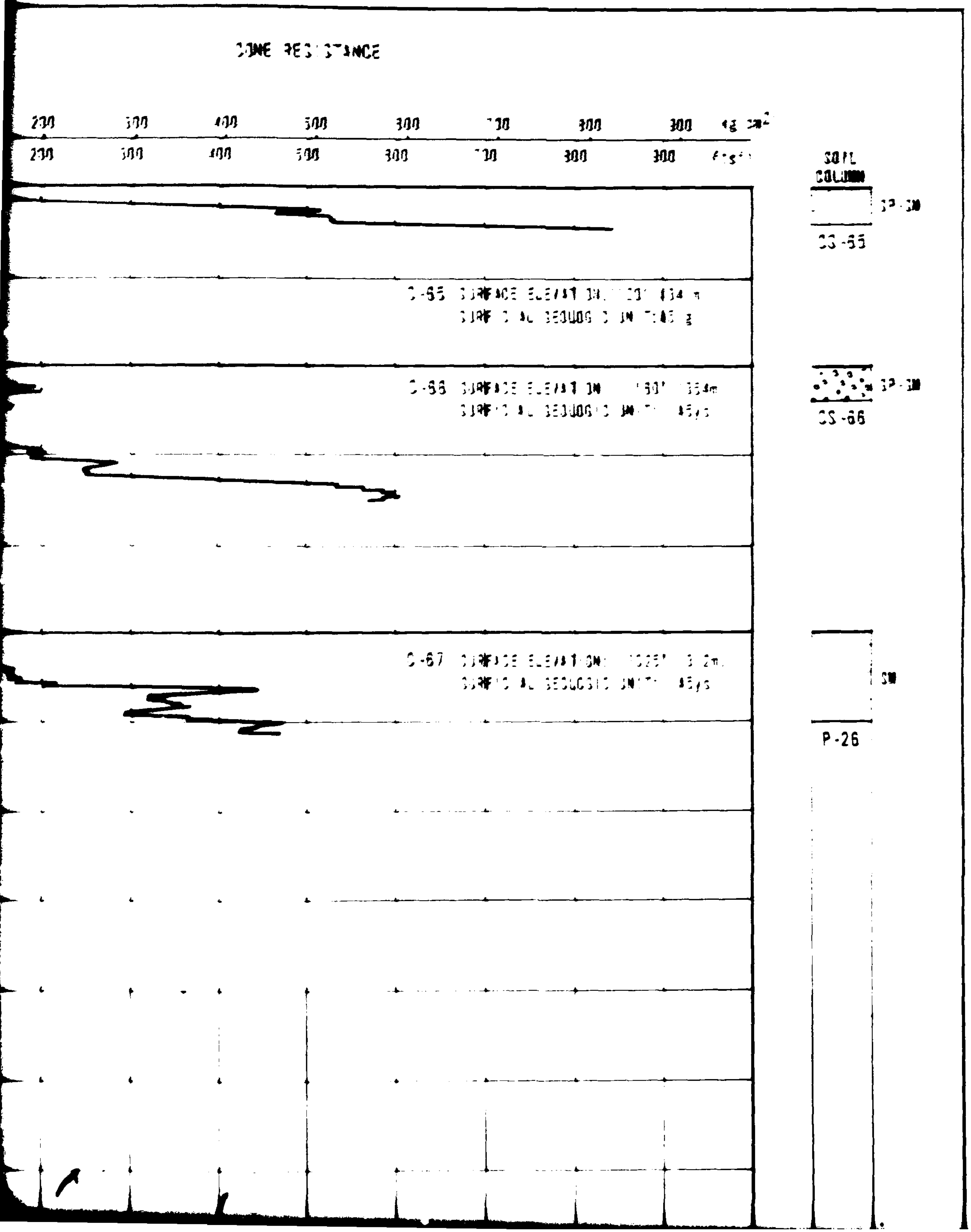
CONE RESISTANCE
DEPTH
(METERS)
(FEET)
800 900 (kg/cm2)
00 900 (tsf)
0 100 200 300 400 500 600
0 100 200 300 400 500 600
SOIL COLUMN
ON: 765' (233m)
OGIC UNIT: A5ig
GM-GC
GM
T-4
ION: 725' (221m)
OGIC UNIT: A1s
SP
P-14
C-51
C-52
C-53
C-54
C-5

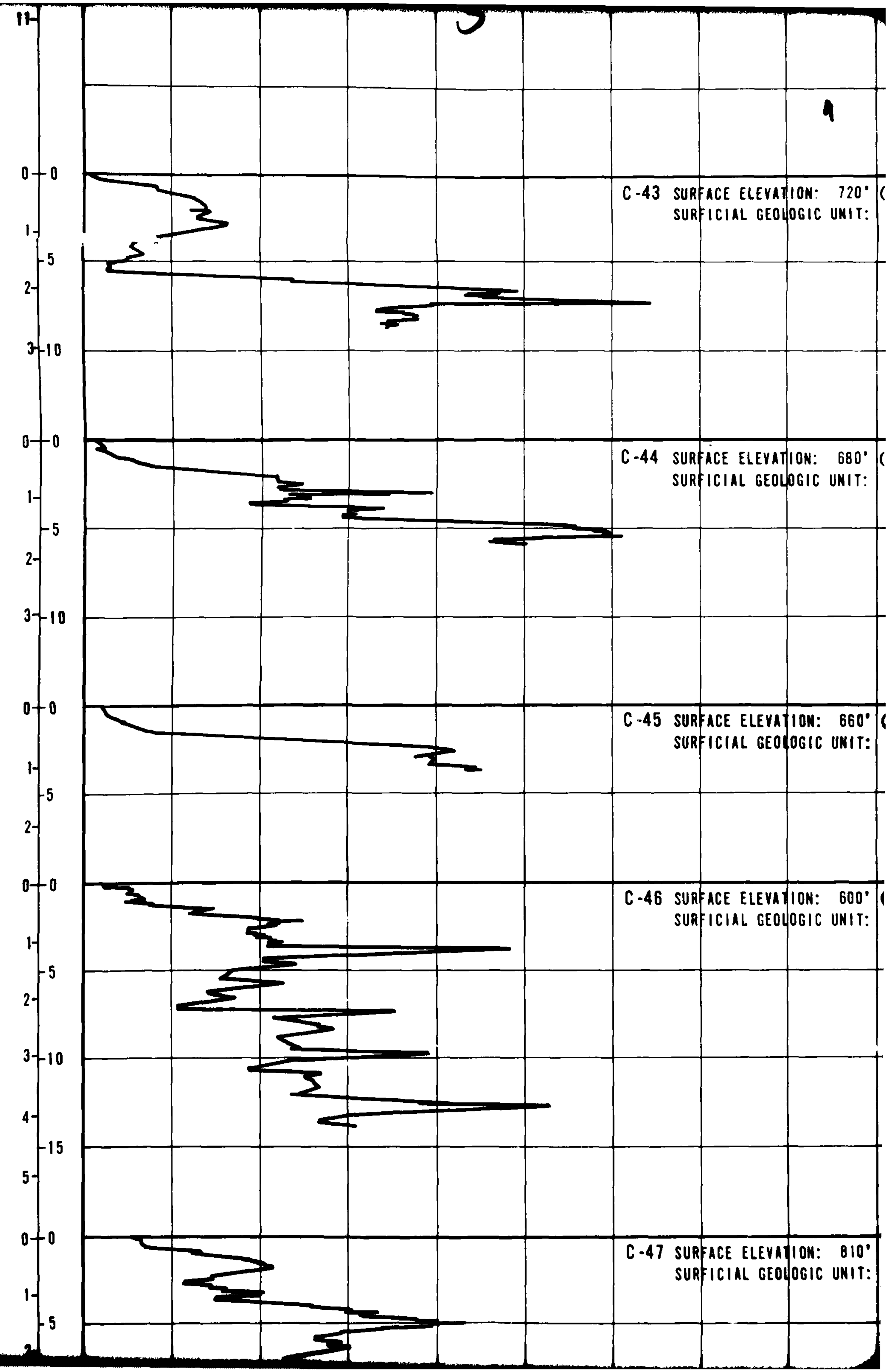
1 3

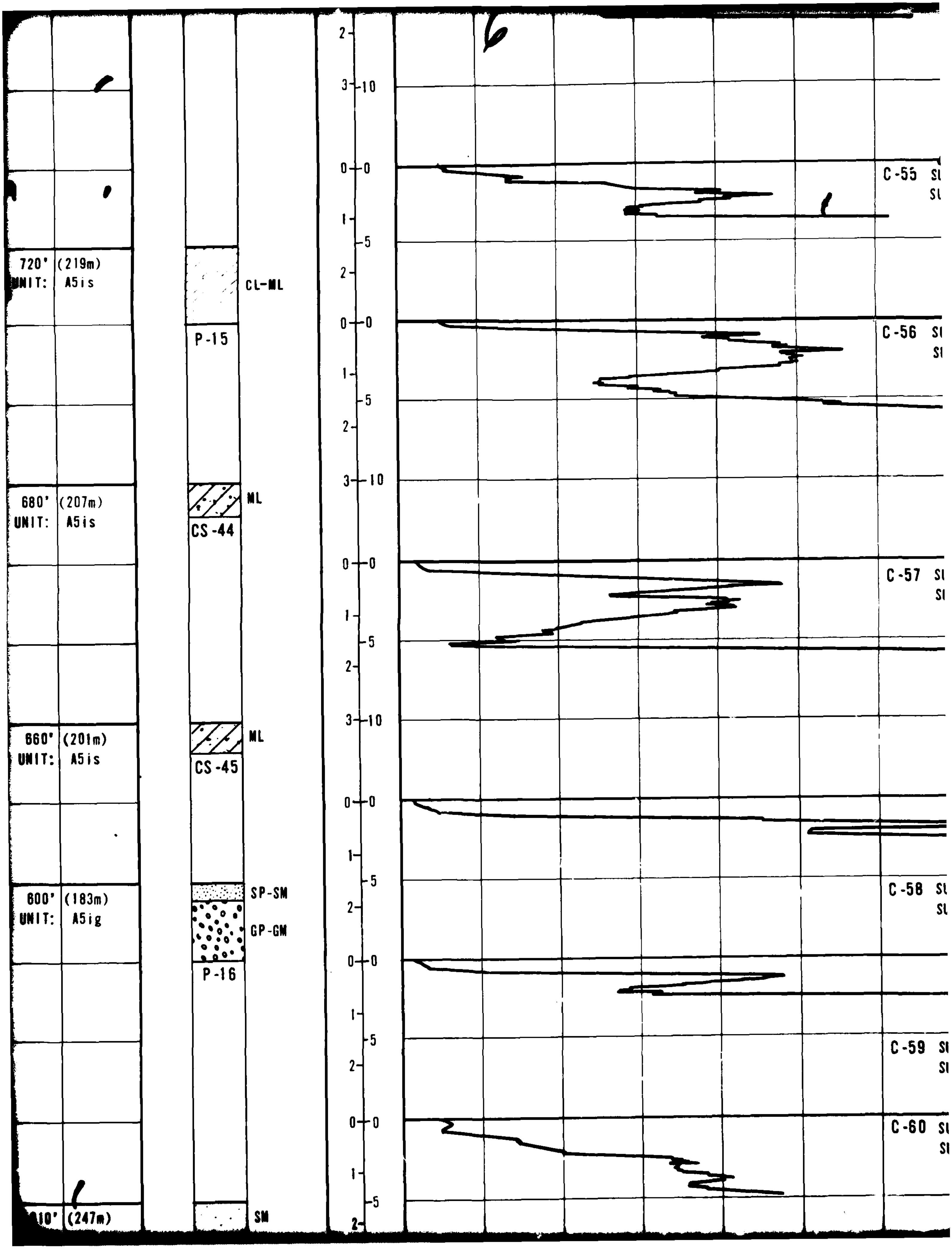


ESISTANCE
500 600 700 800 900 (kg/cm2)
500 600 700 800 900 (tsf)
SOIL COLUMN
DEPTH
(METERS) (FEET)
0 100 200 300
C-51 SURFACE ELEVATION: 1040' (317m)
SURFICIAL GEOLOGIC UNIT: A5ig
SM
CS-51
C-52 SURFACE ELEVATION: 1105' (337m)
SURFICIAL GEOLOGIC UNIT: A5i A1g
C-53 SURFACE ELEVATION: 1160' (354m)
SURFICIAL GEOLOGIC UNIT: A1/A5yg
GW-GM
T-5
C-54 SURFACE ELEVATION: 1240' (378m)
SURFICIAL GEOLOGIC UNIT: A5ig
GP-GM
P-23
C-55 SURFACE ELEVATION: 1340' (408m)
SURFICIAL GEOLOGIC UNIT: A5ig
GM
CS-55

4




C-43 SURFACE ELEVATION: 720' (
SURFICIAL GEOLOGIC UNIT:
C-44 SURFACE ELEVATION: 680' (
SURFICIAL GEOLOGIC UNIT:
C-45 SURFACE ELEVATION: 660' (
SURFICIAL GEOLOGIC UNIT:
C-46 SURFACE ELEVATION: 600' (
SURFICIAL GEOLOGIC UNIT:
C-47 SURFACE ELEVATION: 810'
SURFICIAL GEOLOGIC UNIT:

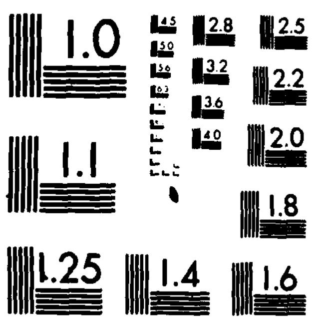


6
720' (219m)
UNIT: A5is
CL-ML
P-15
680' (207m)
UNIT: A5is
ML
CS-44
660' (201m)
UNIT: A5is
ML
CS-45
600' (183m)
UNIT: A5ig
SP-SM
GP-GM
P-16
10' (247m)
SM
C-55
C-56
C-57
C-58
C-59
C-60

AD-A113 416 FUGRO NATIONAL INC LONG BEACH CA F/G 13/2
MX SITING INVESTIGATION. GEOTECHNICAL EVALUATION. VOLUME I. ARI--ETC(U)
NOV 79 F04704-78-C-0027
UNCLASSIFIED FN-TR-28-VOL-1 NL

6 of 6

113416



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

P-23

ACE ELEVATION: 1340' (408m)
ICIAL GEOLOGIC UNIT: A5ig

GM

CS-55

FACE ELEVATION: 1120' (341m)
FICIAL GEOLOGIC UNIT: A5is

GP-GM

P-27

SURFACE ELEVATION: 1090' (332m)
SURFICIAL GEOLOGIC UNIT: A5is

GM
GP-GM

CS-57

GM

8 SURFACE ELEVATION: 1060' (323m)
SURFICIAL GEOLOGIC UNIT: A5is

P-28

SM
GP-GM

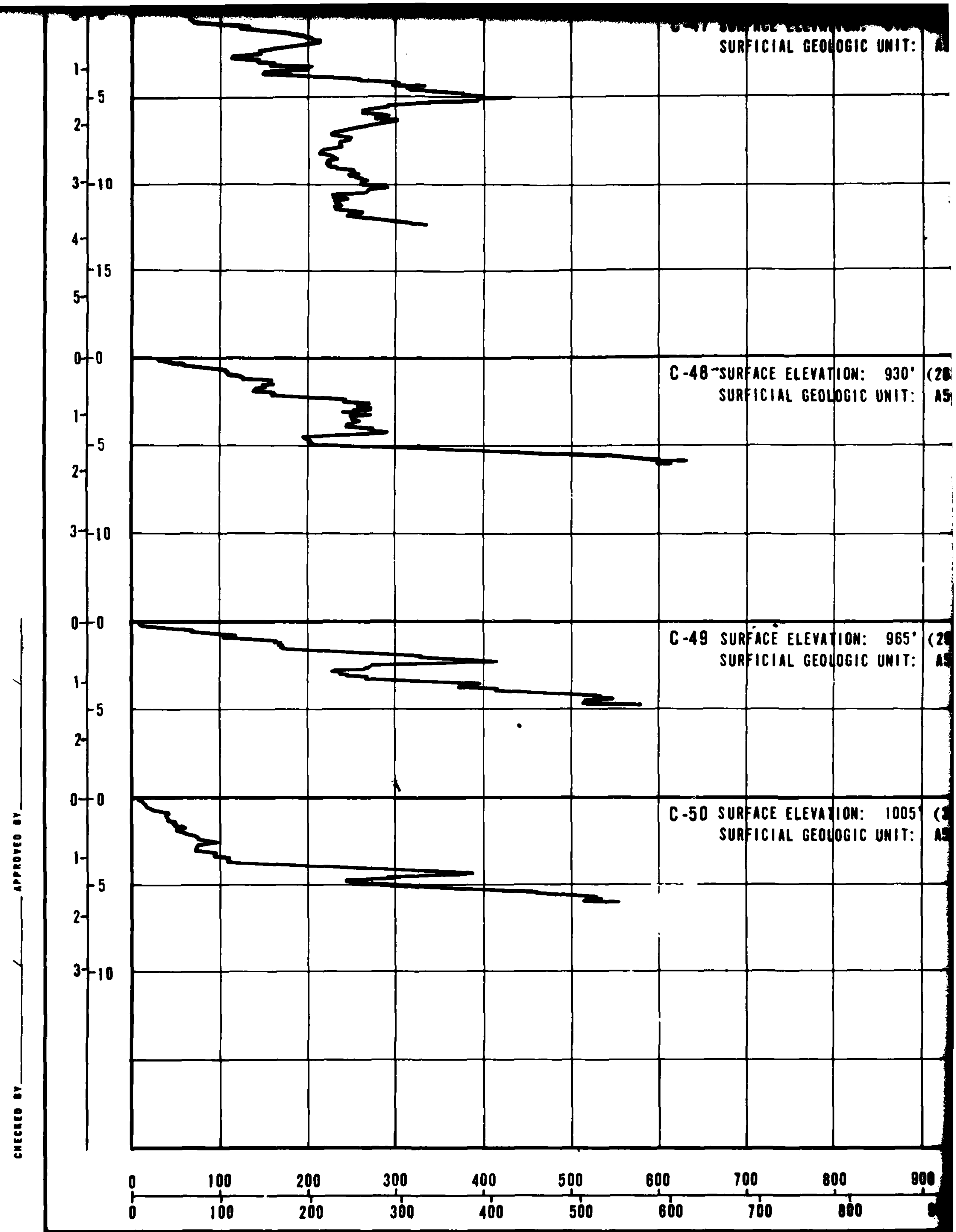
CS-59

9 SURFACE ELEVATION: 1030' (314m)
SURFICIAL GEOLOGIC UNIT: A5is

0 SURFACE ELEVATION: 1000' (305m)
SURFICIAL GEOLOGIC UNIT: A5is

SM

CS-60



SURFICIAL GEOLOGIC UNIT:
C-48 SURFACE ELEVATION: 930'
SURFICIAL GEOLOGIC UNIT:
C-49 SURFACE ELEVATION: 965'
SURFICIAL GEOLOGIC UNIT:
C-50 SURFACE ELEVATION: 1005'
SURFICIAL GEOLOGIC UNIT:
0 100 200 300 400 500 600 700 800 900
0 100 200 300 400 500 600 700 800
CHECKED BY
APPROVED BY

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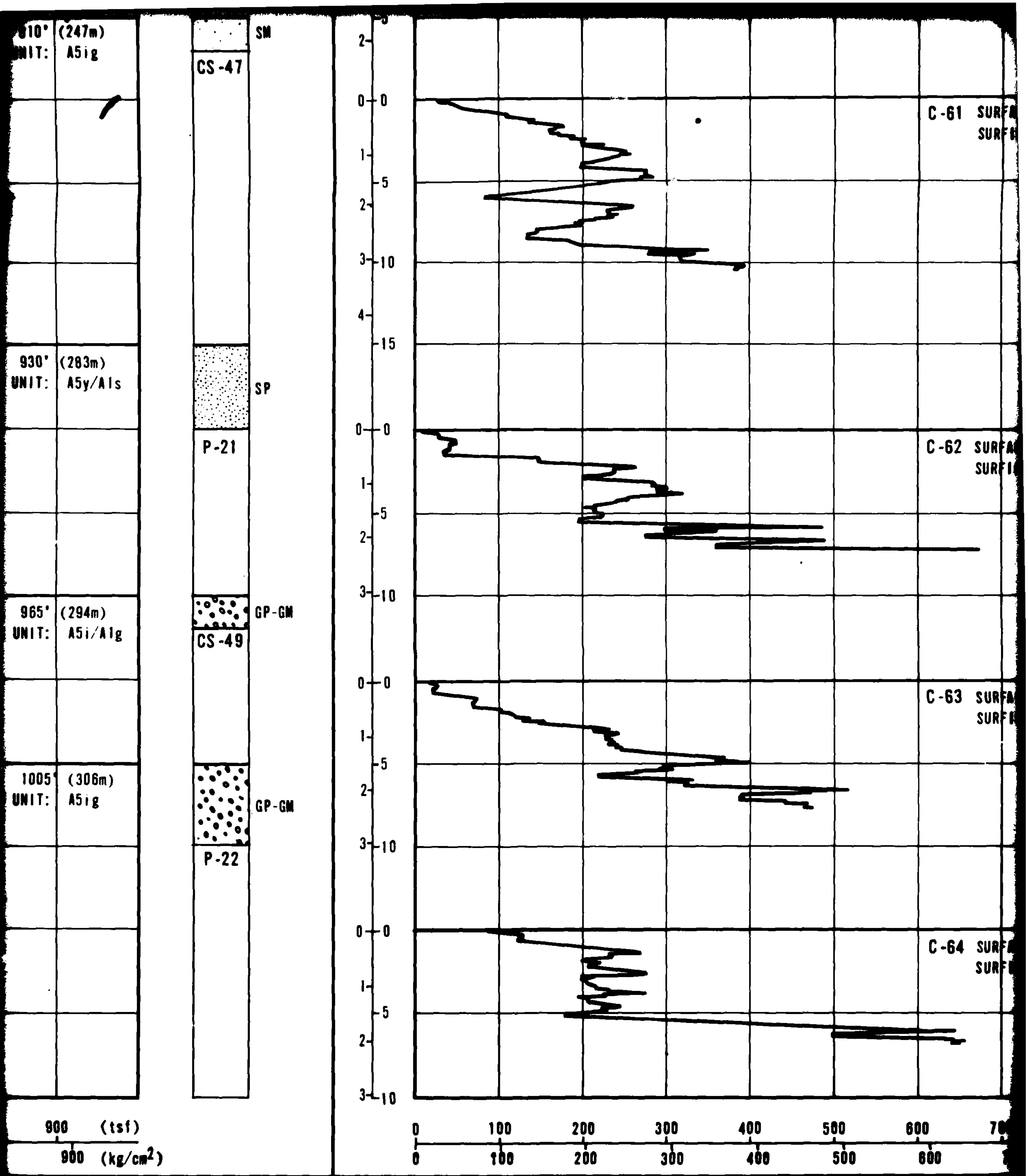
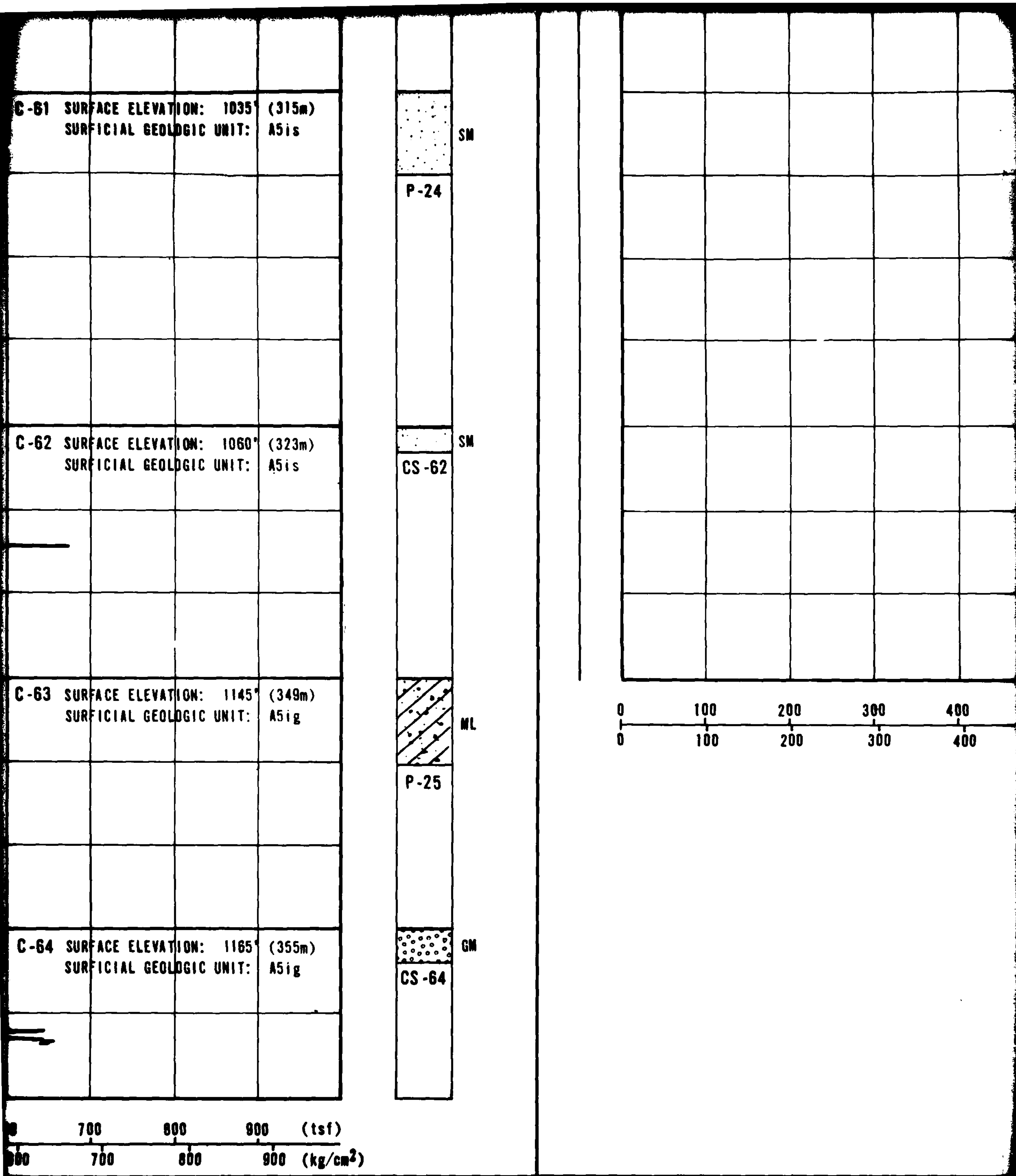
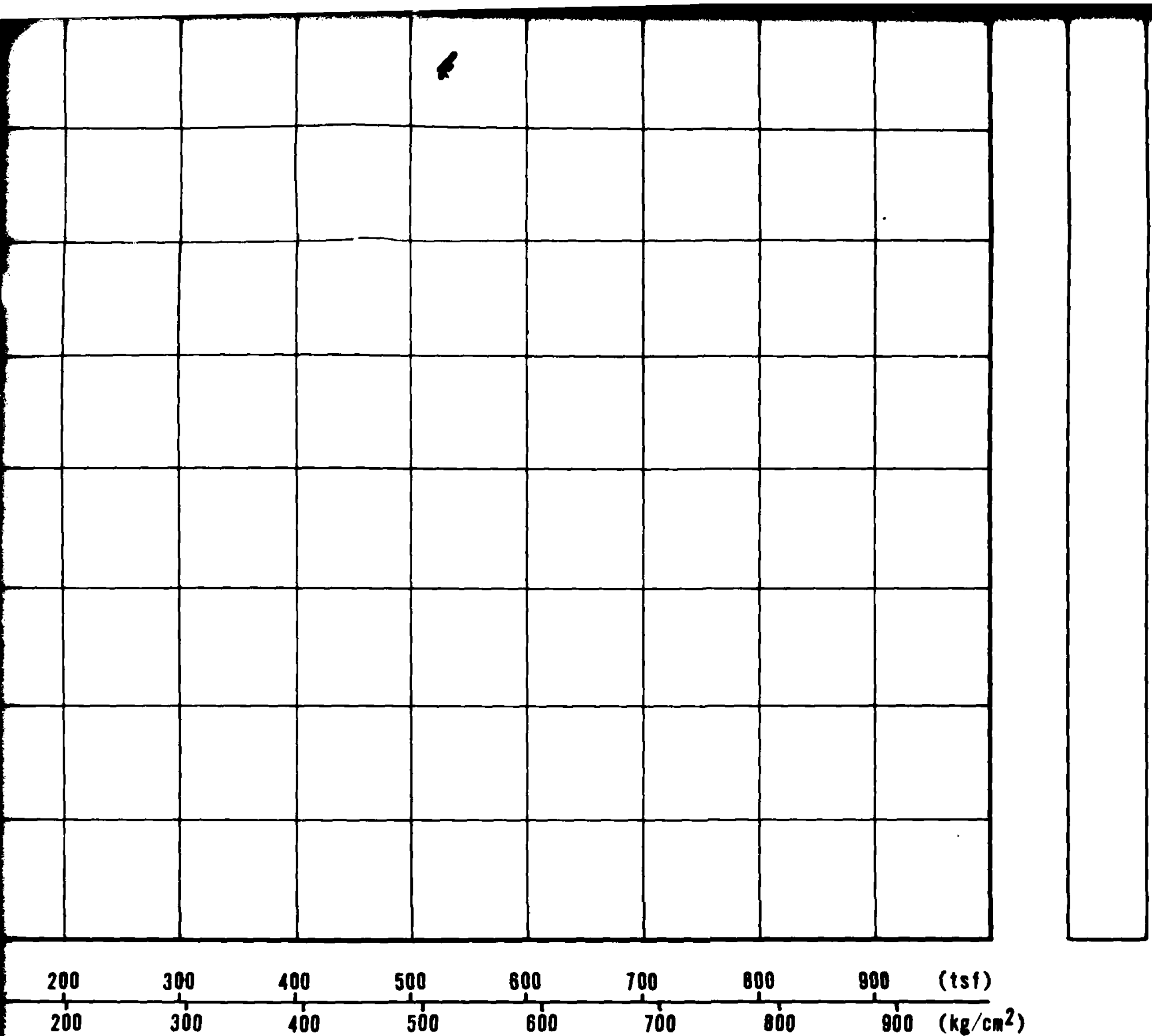


?10' (247m)
UNIT: A5ig
SM
CS-47
930' (283m)
UNIT: A5y/Als
SP
P-21
965' (294m)
UNIT: A5i/Alg
GP-GM
CS-49
1005' (306m)
UNIT: A5ig
GP-GM
P-22
C-61 SURF
C-62 SURF
C-63 SURF
C-64 SURF
900 (tsf)
900 (kg/cm2)
0 100 200 300 400 500 600 70
0 100 200 300 400 500 600


C-61 SURFACE ELEVATION: 1035' (315m)
SURFICIAL GEOLOGIC UNIT: A5is
SM
P-24
C-62 SURFACE ELEVATION: 1060' (323m)
SURFICIAL GEOLOGIC UNIT: A5is
SM
CS-62
C-63 SURFACE ELEVATION: 1145' (349m)
SURFICIAL GEOLOGIC UNIT: A5ig
ML
P-25
C-64 SURFACE ELEVATION: 1165' (355m)
SURFICIAL GEOLOGIC UNIT: A5ig
GM
CS-64
700 800 900 (tsf)
700 800 900 (kg/cm2)
0 100 200 300 400
0 100 200 300 400



CONE PENETROMETER TEST RESULTS
VERIFICATION SITE
LA POSA CDP , ARIZONA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

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2
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1

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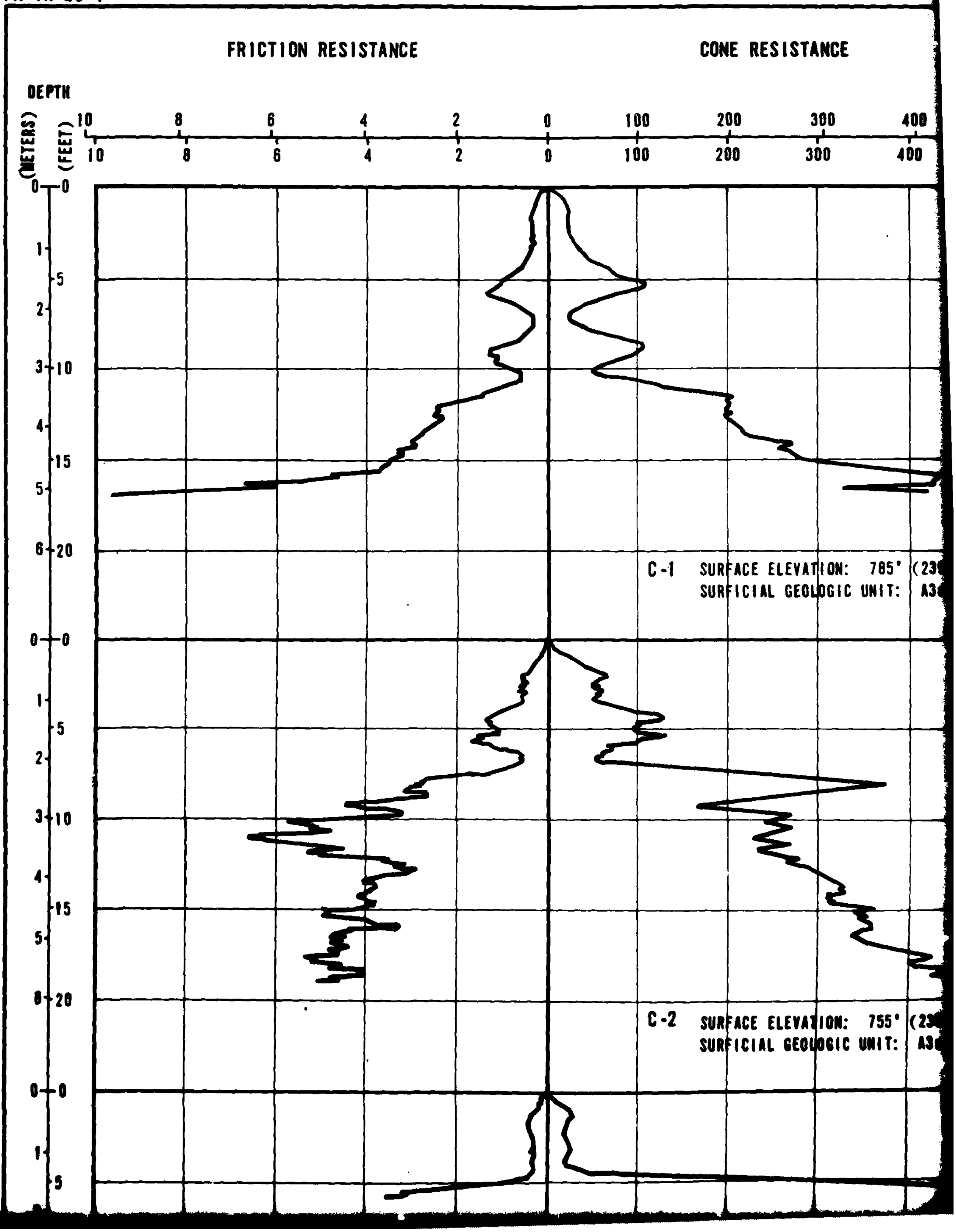
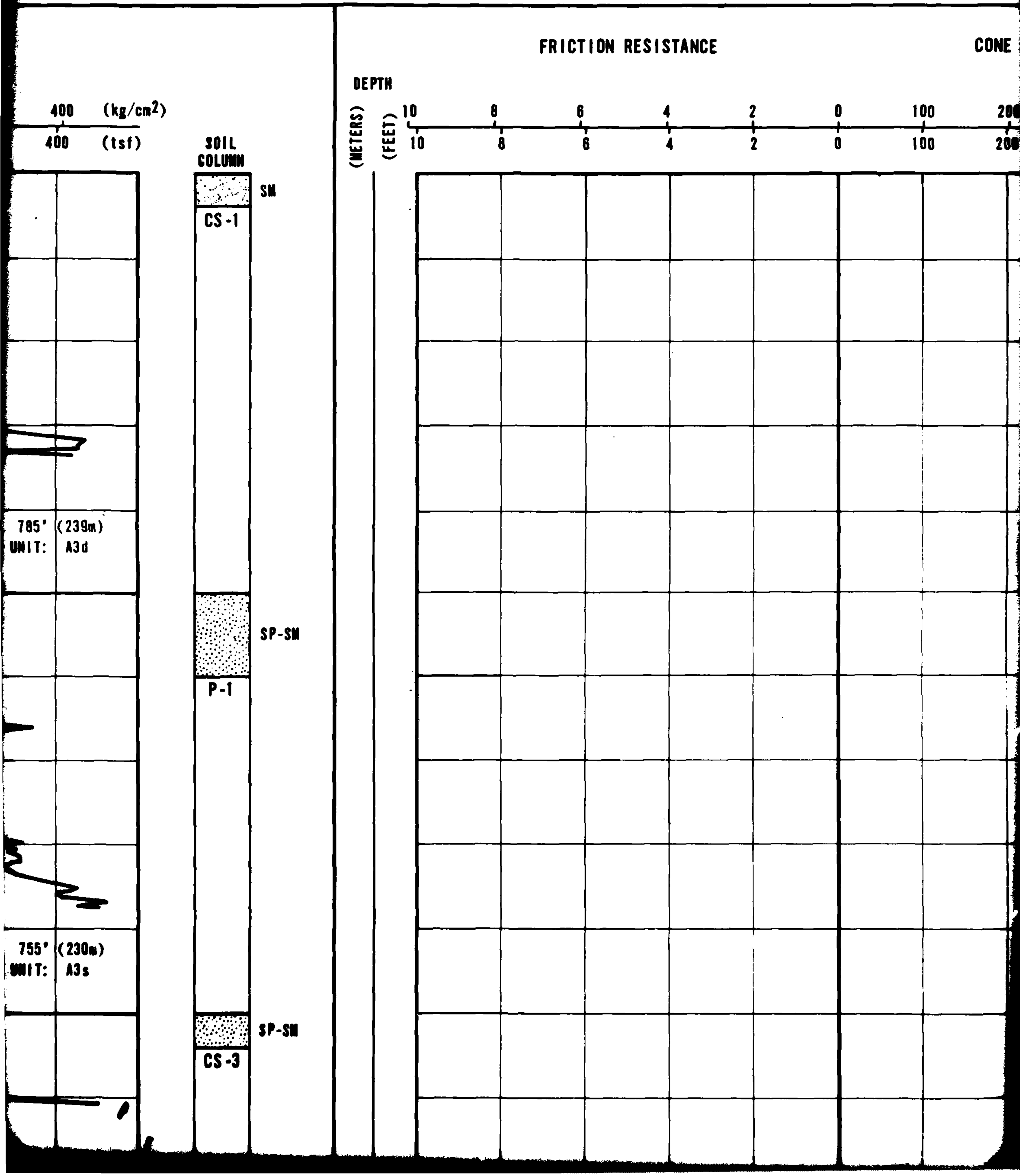

FRICTION RESISTANCE
CONE RESISTANCE
DEPTH
(METERS)
(FEET)
10 8 6 4 2 0 100 200 300 400
C-1 SURFACE ELEVATION: 785' (23
SURFICIAL GEOLOGIC UNIT: A3
C-2 SURFACE ELEVATION: 755' (23
SURFICIAL GEOLOGIC UNIT: A3

1 2


FRICTION RESISTANCE
CONE
DEPTH
(METERS)
(FEET)
10 8 6 4 2 0 100 200
400 (kg/cm2)
400 (tsf)
SOIL COLUMN
SM
CS-1
785' (239m)
UNIT: A3d
SP-SM
P-1
755' (230m)
UNIT: A3s
SP-SM
CS-3

1

3

CONE RESISTANCE

200 300 400 (kg/cm^2)

200 300 400 (tsf)

SOIL COLUMN

DEPTH

(METERS)

(FEET)

FRICTION RESISTANCE

10 8 6 4 2

10 8 6 4 2

1 4

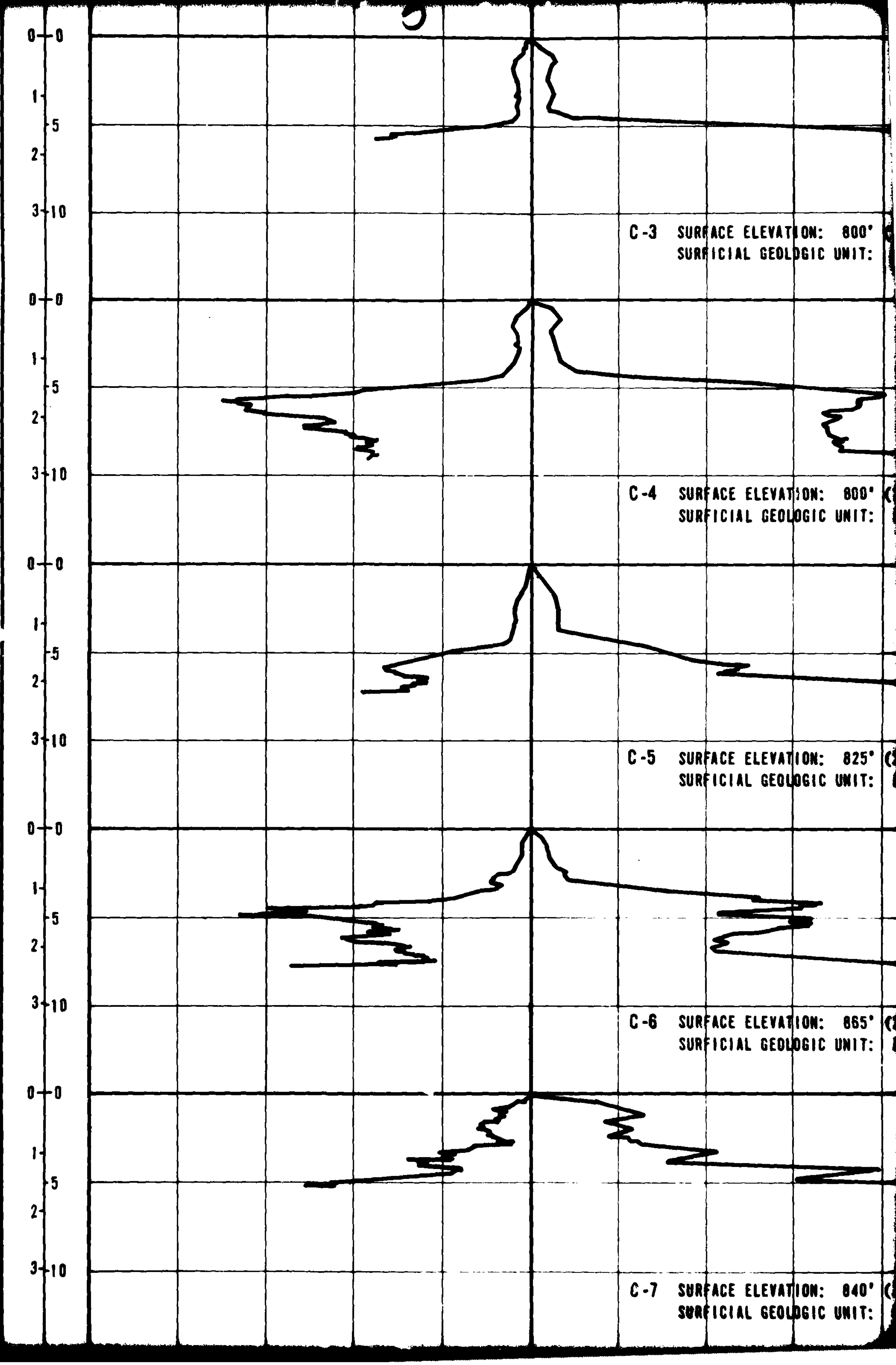
ICTION RESISTANCE

CONE RESISTANCE

6 4 2 0 100 200 300 400 (kg/cm^2)

6 4 2 0 100 200 300 400 (tsf)

SOIL COLUMN


0 0
1 5
2
3 10
C-3 SURFACE ELEVATION: 800'
SURFICIAL GEOLOGIC UNIT:
C-4 SURFACE ELEVATION: 800'
SURFICIAL GEOLOGIC UNIT:
C-5 SURFACE ELEVATION: 825'
SURFICIAL GEOLOGIC UNIT:
C-6 SURFACE ELEVATION: 865'
SURFICIAL GEOLOGIC UNIT:
C-7 SURFACE ELEVATION: 840'
SURFICIAL GEOLOGIC UNIT:

...ON: 755' (230m)
...GIC UNIT: A3s

SP-SM

CS-3

...ON: 800' (244m)
...GIC UNIT: A3s

SP-SM

T-1

...ATION: 800' (244m)
...OLOGIC UNIT: A3d

SP

P-2

...VATION: 825' (251m)
...EOLOGIC UNIT: A3d

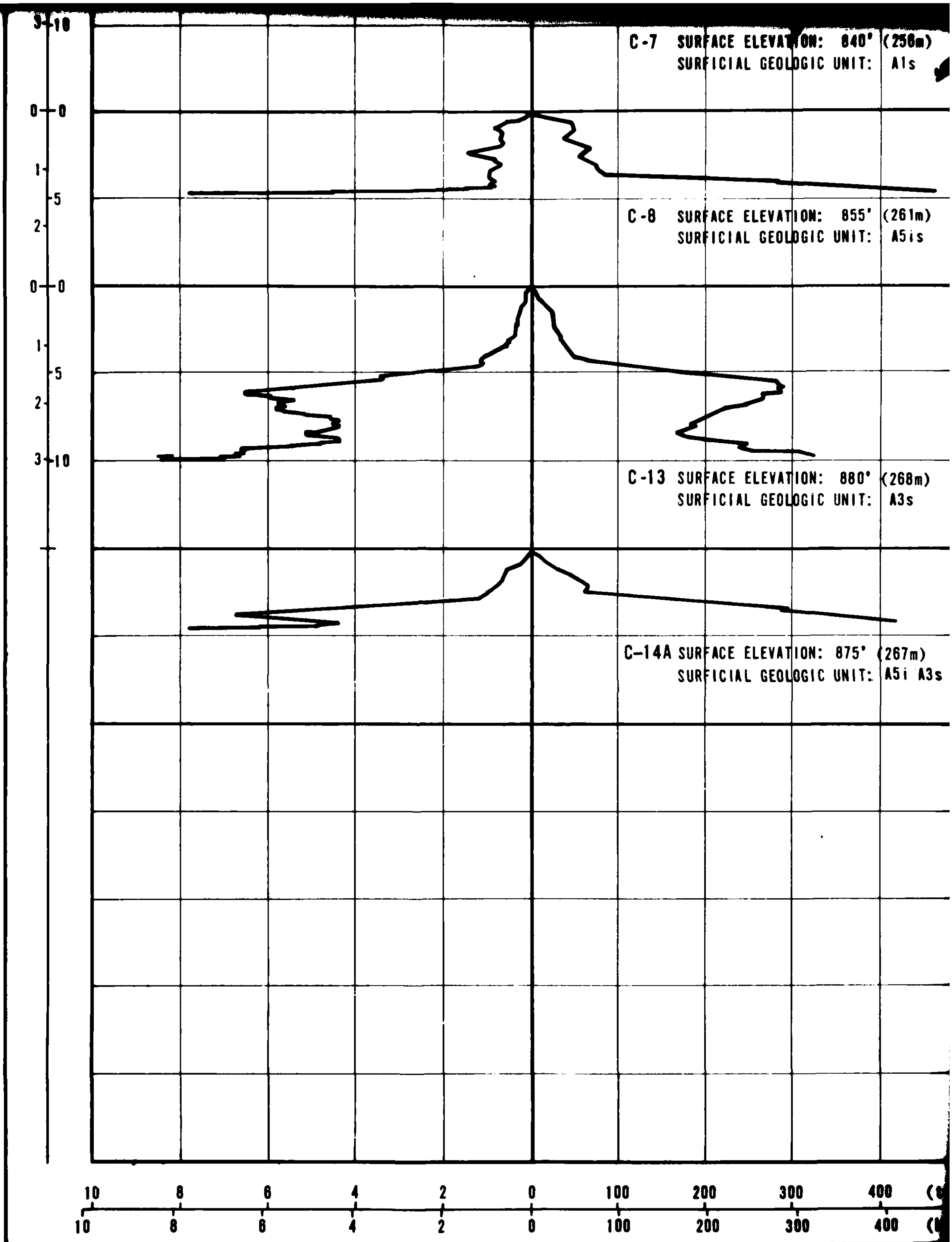
SM

CS-6

...EVATION: 865' (264m)
...EOLOGIC UNIT: A3s

GP

P-3



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UNIT: A1s

SM
CS-8

855' (261m)
UNIT: A5is

SM
P-5

880' (268m)
UNIT: A3s

SC-SM
CS-14

875' (267m)
UNIT: A5i A3s

400 (tsf)
400 (kg/cm²)

10 8 6 4 2 0 100 200
10 8 6 4 2 0 100 200

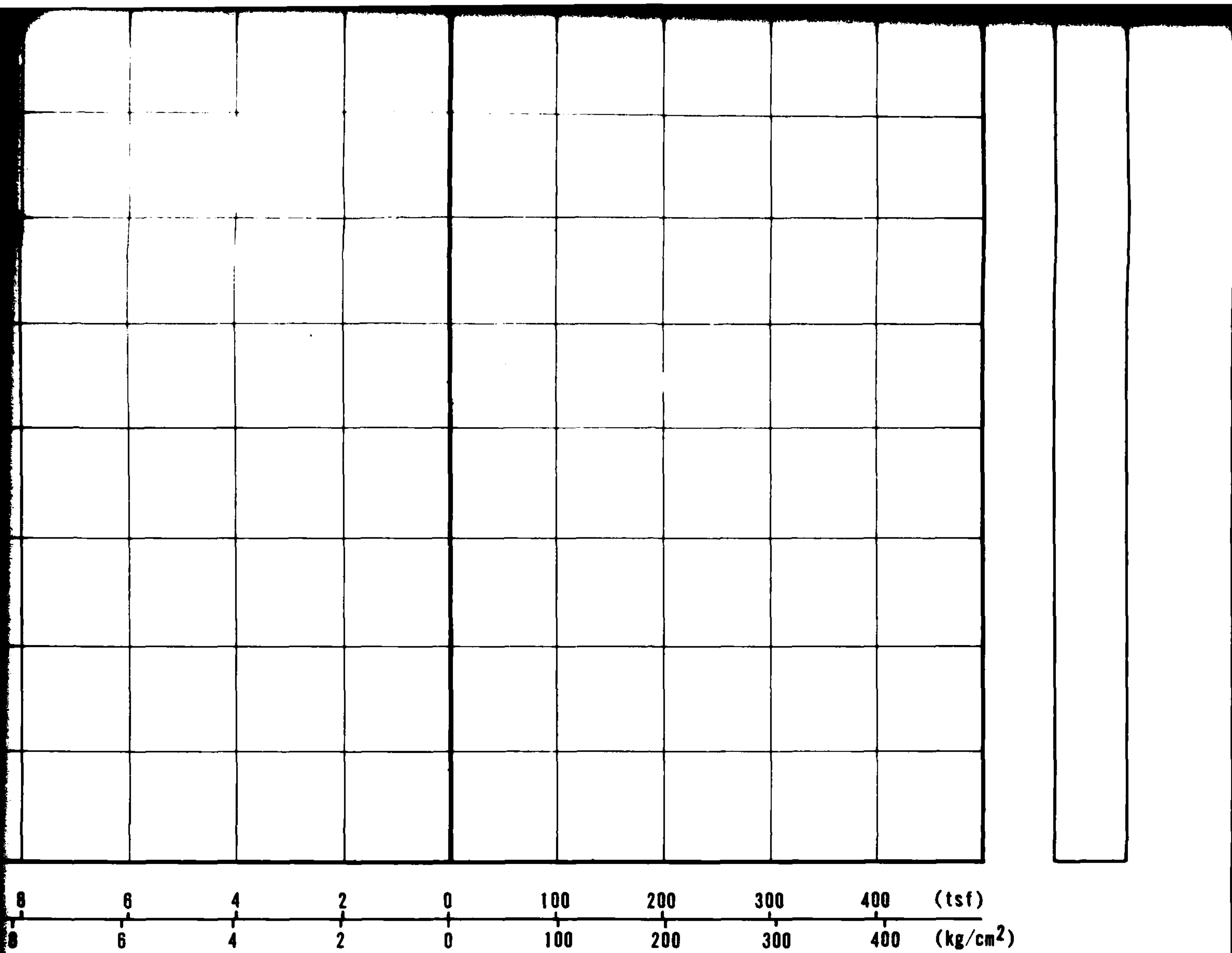
10

100 200 300 400 (tsf)

100 200 300 400 (kg/cm^2)

10 8 6 4 2

10 8 6 4 2



CONE PENETROMETER TEST RESULTS
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